THE UNIVERSITY OF ALBERTA

A COMPARATIVE STUDY OF NORTH PACIFIC AND CANADIAN ARCTIC HERRING (Clupea)

A DISSERTATION

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OF MASTER OF SCIENCE

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Frontispiece. Arctic herring and lamprey from Tuktoyaktuk, N. W. T.

ABSTRACT

Comparisons of meristic characters and body proportions of samples of Clupea from Walker Rock (British Columbia), Afognak Island (Alaska), Tuk (Northwest Territories), and Husky Lakes (Northwest Territories) showed that Pacific and Arctic herring could be distinguished by significant differences in mean "diameter" of scales at end of first year, mean numbers of abdominal vertebrae, mean numbers of lateral line scales, and eye diameter, expressed as a percentage of head length. Mean numbers of total vertebrae, abdominal vertebrae, "keel" scales, lateral line scales, and gill rakers increase from south to north, but the mean number of branchiostegal and pectoral fin rays decreases from south to north. Herring from southern waters possess relatively larger heads, upper jaws, snout lengths, and eye diameters, but smaller postorbital lengths and interorbital widths than herring from more northern waters. Means $\pm$ 3 standard deviations for the various meristic characters show very similar overlapping ranges for the populations from which the samples were drawn. The differences in mean numbers, often statistically significant, between localities as well as differences in body proportions presumably are caused by environmental factors which are known to influence growth and development. Evidence indicates that herring from western Arctic Canada and those from the Pacific Ocean constitute one taxonomic unit, Clupea harengus pallasi Val.

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INTRODUCTION

A Clupea species has been known to exist in Arctic Canada since Richardson described it in 1823, but the present study is the first on the morphology and life history of the species from ~~this~~ that area.

Samples of herring from Walker Rock, British Columbia (197 specimens); Afognak Island, Alaska (12 specimens); Tuk (Port Brabant), Northwest Territories (211 specimens); and Husky (Eskimo) Lakes, Northwest Territories (22 specimens), provided the data for this study of the systematic relationship between the well-investigated herring of the North Pacific and the little-known herring of Arctic Canada.

CLASSIFICATION AND DISTRIBUTION

The herring of the Pacific and Arctic Oceans are presently listed as *Clupea harengus pallasi* Valenciennes 1847 (Svetovidov, 1952).

According to Andriashev (1954), *Clupea harengus* Linnaeus, the Atlantic herring, was first described in the tenth edition of *Systema Naturae* in 1758. *Clupea harengus* (non L.) Pallas was described from Kamchatka specimens in 1811. Cuvier and Valenciennes re-examined Pallas's Kamchatka material and listed the herring as *Clupea pallasi* in 1847. *Clupea harengus pallasi* Schmidt appeared in *Fishes of the Eastern Seas* in 1904 (Andriashev, 1954).

There is at present no agreement on the taxonomic status of the two groups: the Atlantic *harengus* and the Pacific-Arctic *pallasi*. Some authors (Schmidt, Berg, Rabinerson, Svetovidov, and others) consider the two groups as subspecies while others (Heincke, the ichthyologists of the United States and Canada, Averinsev, Schnakenbeck, Rass, Ponomareva, and others) consider them as independent though related species (Andriashev, 1954). Andriashev (1954) summarizes the main differences between the Murmansk and the Pacific-Arctic herring as follows:

1 (2) Usually 56 to 58 vertebrae. Keeled scales more or less developed posteriorly, usually 14 to 15, and

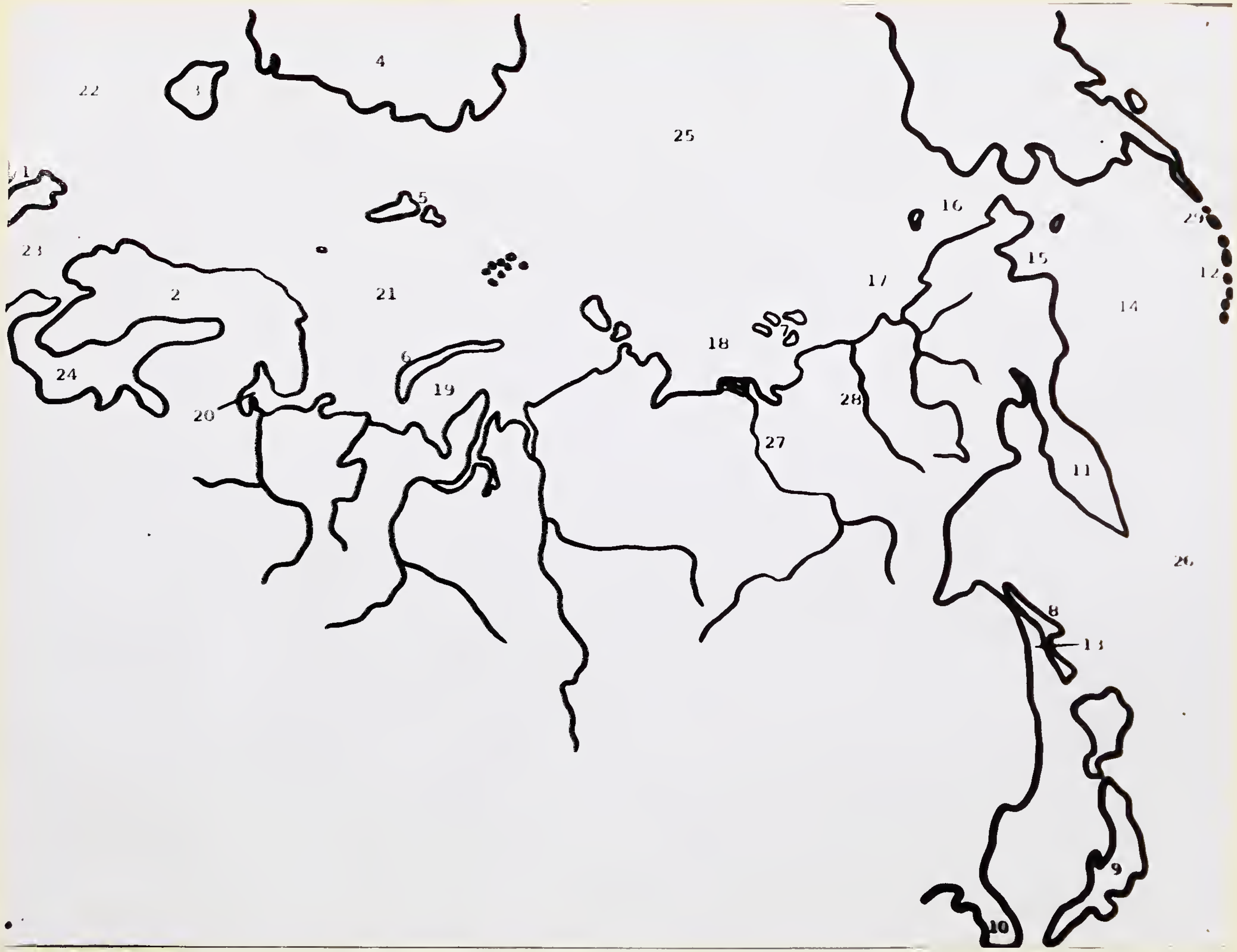

Figure 1. Map of northern Europe and Asia showing areas and localities mentioned in text. 1. British Isles. 2. Scandinavia. 3. Iceland. 4. Greenland. 5. Spitzbergen 6. Novaya Zemlya. 7. New Siberian Islands. 8. Sakhalin. 9. Japan. 10. Korea. 11. Kamchatka. 12. Aleutian Islands. 13. Tartar Bay. 14. Bering Sea. 15. Gulf of Anadyr. 16. Chukchi Sea. 17. East Siberian Sea. 18. Laptev Sea. 19. Kara Sea. 20. White Sea. 21. Barents Sea. 22. Atlantic Ocean. 23. North Sea 24. Baltic Sea. 25. Arctic Ocean. 26. Pacific Ocean. 27. Lena River. 28. Indigirka River. 29. Unalaska.

anterior to the pelvic fins. Teeth on the vomer comparatively well developed. Eggs are deposited on the bottom at great depths. Found in the Barents Sea and south of it; enters the White Sea . . . *Clupea harengus harengus* L.

2 (1) Usually 52 to 57 vertebrae. Keeled scales more or less developed only posterior to the pelvic fins, usually 11 to 12. Teeth on vomer less developed, fewer in number. Eggs deposited along shore, usually on vegetation. Found in the northern part of the Pacific Ocean and adjacent Arctic seas . . . . *Clupea harengus pallasi* Val.

Svetovidov (1954) classifies the Atlantic herring as follows: *Clupea harengus harengus* L. found in the northern part of the Atlantic Ocean, North Sea, Barents Sea, and White Sea; *Clupea harengus harengus* natio *membras* L. found exclusively in the Baltic Sea. The Baltic herring have a slightly lower vertebral count (55.2 to 55.7), longer pectoral fins, and a slightly longer head than the Atlantic herring.

Clupea harengus harengus is found in the northern part of the Atlantic Ocean and partly in adjacent Arctic waters (Fig. 1). In the western part of its range it is found from the northern shores of Europe from the Bay of Biscay along to Spitzbergen and eastward to Novaya Zemlya.

Svetovidov classifies the Pacific-Arctic herring as follows: *Clupea harengus pallasi* Val. found in the northern part of the

Figure 2. Map of northwestern North America showing areas and localities mentioned in the text. 1. British Columbia. 2. Northwest Territories. 3. Yukon. 4. Alaska. 5. Alaska Peninsula. 6. Walker Rock. 7. Barkley Sound. 8. Jap Inlet. 9. Prince William Sound. 10. Afognak Island. 11. Shumagin Islands. 12. Norton Sound. 13. Point Barrow. 14. Tuk. 15. Husky Lakes. 16. Liverpool Bay. 17. Cape Bathurst. 18. Cape Parry. 19. Darnley Bay. 20. Bathurst Inlet. 21. Coppermine River. 22. Great Slave Lake. 23. Mackenzie River. 24. Beaufort Sea. 25. Arctic Ocean. 26. Pacific Ocean.

Pacific Ocean and the bordering Arctic Seas. The subspecies is considered to exist as two nations, maris-albi Berg in the White Sea, and suworowi Rabinerson from the White Sea entrance to the East Barents Sea east to the Gulf of Ob.

Clupea harengus pallasi is found in the northern part of the Pacific Ocean and partly in the Arctic Seas. At the shores of Asia it is common from the western coast of Korea north to the Gulf of Anadyr. There have been no herring taken from the Chukchi and East Siberian Seas, but recently Clupea have been reported from the Laptev Sea (Andriashev, 1954). According to Svetovidov, in 1952, unreliable reports do exist for Lyakhov Is. in the New Siberian Islands and Chaum Bay in the East Siberian Sea (Andriashev, 1954). Walters (1955) says it most likely occurs off the mouth of the Indigirka River in the East Siberian Sea. At the shores of North America, herring are found from southern California to northwestern Alaska and west to the Aleutian Islands (Fig. 2). Walters (1955) reported Clupea collected off Point Barrow, Alaska.

Herring are fairly well known in western Arctic Canada. Richardson (1823) reported Clupea taken near the mouth of the Coppermine River. According to Andriashev (1954), Richardson's is the first reliable report from the Canadian Arctic and tells of herring caught on May 5, 1821. Anderson (1913) reported herring from Cape Bathurst. Great numbers appear at that location during the latter part of August. On August 3, 1911, one run of a 200

foot sweep net is reported to have drawn in 13 barrels, approximately 3,000 herring. Walters (1955) mentioned Clupea from Cape Bathurst and the Mackenzie River delta. Hunter (pers. comm.) collected herring at Tuk and Husky Lakes in September, 1955. The author found Clupea at Whitefish Station, east of the mouth of the Mackenzie River in 1956, and collected herring at Tuk in 1958 in sufficient numbers to make a valid comparative study possible. Father Metayer (pers. comm.), Arctic missionary, reported Clupea, the Eskimo "blue herring" or western dialect "pirkroartitak", commonly found at Paulatuk on Darnley Bay east of Cape Parry.

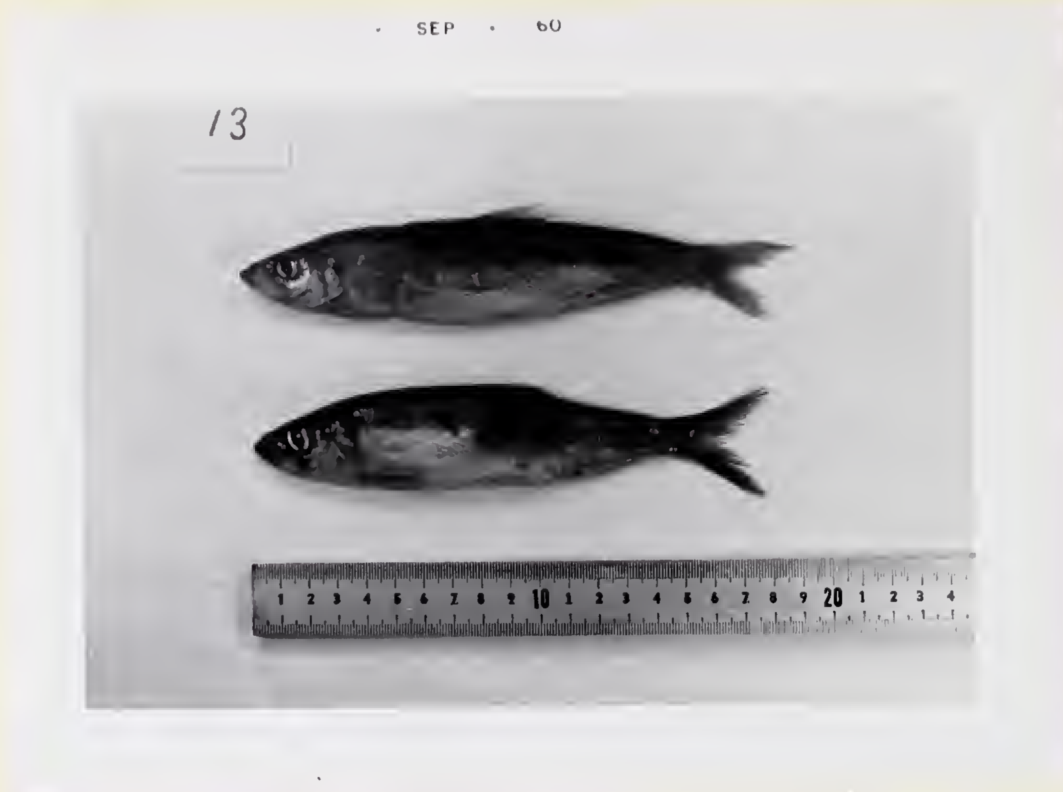

Fig. 3. Preserved herring from Tuk (top), 175 millimeters, fresh fork length, and Walker Rock (bottom), 163 millimeters, corrected fork length.

Fig. 4. Preserved herring from Tuk (top), 208 millimeters, fresh fork length, and Walker Rock, (bottom), 213 millimeters, corrected fork length.

DESCRIPTION

Clemens and Wilby (1946) give the following description for the Pacific herring (Clupea pallasii Valenciennes 1847):

"Body elongate, depth about 4 in standard length, moderately compressed. Head compressed; mouth terminal, moderate; lower jaw projecting; maxillary reaching to point below eye; teeth, absent from jaws, on vomer in form of ovate patch, on tongue small, weak; no striae on operculum. Fins: dorsal (1), 15 to 21; anal, 14 to 40 (sic): pelvic, abdominal, each with fleshy appendage at base, origin slightly behind that of dorsal; caudal, furcate. Lateral line: absent. Scales: cycloid; in oblique rows above midline of body, 51 to 54; on ventral surface modified as very weakly keeled scutes anterior to pelvic fins, more strongly keeled between pelvic fins and anus; on side of tail, not modified. Colour: bluish green on dorsal surface; silvery on ventral surface; black spots absent from sides of body; dusky on peritoneum.

Length to 18 inches."

Figures 3 to 7 show herring from Walker Rock and Tuk.

Fig. 5. Preserved female herring from Tuk,
322 millimeters, fresh fork length.

Fig. 6. Preserved male herring from Tuk,
307 millimeters, fresh fork length.

Fig. 7. Freshly caught herring from Tuktoyaktuk, N. W. T., September, 1958. Knife: 238 millimeters in length.

LIFE HISTORY

The Atlantic herring spawn in deep water, on gravelly bottom at depths from 40 to 300 meters, whereas the life cycle of the Pacific herring is associated to a great extent with the coastal and brackish waters of bays and river mouths. Pacific herring spawn on vegetation which grows near shore, such as eelgrass and seaweed, and occasionally on pebbles, in shallow water to a depth of 10 meters. Spring, summer, fall, and winter spawning herring are distinguished among the Atlantic herring. The Pacific herring breed only in spring and spawn from December to June according to locality, the spawning time being progressively later towards the northern and western portions of their range (Rounsefell, 1930). Herring breed in southern California in December and January, British Columbia from late February to April, and Alaska and the Bering Sea in May and June. Andriashev (1954) mentioned ripe specimens caught in the Laptev Sea in August.

During the fall and early winter, the British Columbia herring appear in numerous schools near shore and remain in these waters throughout the winter until spawning in the following spring. Spawning activity on a bed lasts from one to several days. The pale yellow, translucent eggs are cemented to vegetation in clusters by the hardening of a sticky mucilaginous coat. The female is closely followed by the male which covers the attached eggs with a stream of milt. Great quantities of milt may form a dense greenish-white cloud in the water, sometimes as great as a mile in length

and one-quarter of a mile in width (Tester, 1935). Kamchatka herring breed around the middle of May in brackish water (20 to 23 $^{o}/oo$) from the water's edge to depths of three or four meters at water temperatures of three to six degrees Centigrade.

Herring eggs develop at six to eight degrees Centigrade in about 23 days and the hatched larvae are seven to eight millimeters in length (Andriashev, 1954). Turner (in Andriashev, 1954) described similar conditions for herring in Norton Sound, Alaska, where the peak of breeding occurs in June at water temperatures of six to seven degrees Centigrade. Tester (1935) reported that British Columbia herring hatch in 10 to 20 days, the time depending on the temperature of the water.

The loss of eggs because of tidal fluctuation has been estimated at 25 percent (Andriashev, 1954). Exposure by low tide gives predators including gulls, ducks, and crows access to the eggs. Sun, wind, and frost also take their toll, but exposed eggs have a remarkable resistance to these agencies (Tester, 1935).

The newly hatched larvae, five to eight millimeters long with a ventral bulge marking the position of the yolk sac, can swim feebly but are carried along by currents and tidal action. This pelagic stage is probably the most critical period of the life history of the herring because the larvae fall easy prey to other fishes or they may starve because of lack of suitable food when the embryonic supply is gone (Tester, 1935). After one month, the larvae are about 25 millimeters in length. They now move actively

about in schools and appear at the surface at dusk, causing fine ripples on the water and occasionally breaking the surface. During the summer the young herring are present in shallow waters near shore and grow to a length of 70 to 100 millimeters. They are rarely seen in winter because they go to deep waters. Some are seen in the following fall and winter, now about 170 millimeters long, when they come near shore with mature fish which will soon spawn. In southern British Columbia, herring in their third summer are sometimes found in great numbers in inshore waters. These young herring join the adult schools in fall and winter and comprise 20 to 60 percent of the annual commercial catch in British Columbia. Three-year-old fish, about 215 millimeters in length, spawn for the first time in the spring. In northern British Columbia and Alaska, the majority of recruits mature later and join the adult schools in their fourth year (Tester, 1935). The herring continue to grow and reproduce annually. Pacific herring up to 330 millimeters long and 15 years old have been caught, but the commercial catch is made up of fish in their second to fifth years, with the bulk of the catch three and four years old.

The herring is a plankton feeder throughout life. At first, herring feed on minute planktonic organisms such as microscopic eggs of small marine animals. Other food includes diatoms, nauplii of copepods, and larvae of molluscs. The fingerling stage feeds on larger food such as juvenile and adult copepods. Large copepods and schizopods are fed upon by herring of commercial size. The

main food of the Arctic herring is Calonida and Euphausiidae, also Sagitta, Themisto and Mysidae (Andriashev, 1954).

Kuhn (in Andriashev, 1954) distinguished the following feeding periods in the herring of Tartar Bay:

1. Spring or pre-breeding--April to May.
2. Breeding starvation--May to June.
3. Intensive summer feeding--from the end of June to August.
4. Fall drop in intensity of feeding.

Tester (1935) reported that British Columbia herring rarely contain food at times of the year other than in spring after spawning, and during the summer.

The developing eggs of herring are attacked by birds; the larvae are eaten by small fishes and other marine animals. Young and adults provide food for economically important species including spring and coho salmon, steelhead trout, lingcod, halibut, and dog-fish. Gulls, seals, sea lions, and man also take their toll.

RACIAL INVESTIGATIONS IN FISHES AND FACTORS INFLUENCING VARIATIONS IN MERISTIC CHARACTERS AND BODY PROPORTIONS

The study of marine fish populations developed because of fluctuations in numbers of economically important species. Workers of the Scandinavian countries and Great Britain have long been studying fish populations. An important result of this work has been the recognition and description of local races within species. These local races are more or less separate populations, each with its own area of distribution and area of spawning, and characterized by differences in the means of certain meristic characters and body proportions. Heincke, as early as 1882, made elaborate investigations on varieties of Baltic Sea and North Sea herring. Heincke is usually given credit for showing the existence of races among herring. According to Dymond (1948), Heincke, in the Natural History of Herrings (1898), showed that herring from different areas have characteristics peculiar to themselves. Heincke believed that local populations could be identified by their body proportions and by the numbers of certain structures, and used the following characters: head length, distance from head to other parts of the body, number of vertebrae, numbers of rays in certain fins, and number of scales along the ventral surface of the body. Matthews, in the 1880's, used 14 body proportions, fin ray counts, and keeled scale counts in studying differences between summer and winter herring of the

Scottish coasts. Matthews emphasized the necessity of examining large numbers of specimens to obtain reliable data but also mentioned the "amount of almost 'drudgery' entailed in an investigation of this sort."

Early workers used large numbers of characters, but later workers used fewer characters which permitted the examination of larger numbers of individuals. According to Dymond (1948), Schmidt, in 1930, used two characters, the number of vertebrae and the number of rays in the second dorsal fin, in a study of the North Atlantic cod. Schmidt found that these numbers increased from south to north, with the lowest values west of the British Isles and the highest in northern Norway. In American waters, the lowest vertebrae values were found off the coast of the United States and the highest values off northern Labrador and Newfoundland. Schmidt also noted an increase in the number of vertebrae and second dorsal fin rays from east to west as well as marked differences in the same characters between cod from shallow, inshore waters and deeper, offshore waters, the latter possessing higher numbers. Schmidt also investigated Danish races of Zoarces viviparus and found wide character variations among neighbouring populations. The residents within the fjords had up to nine fewer vertebrae than those living outside. Fish with intermediate vertebral numbers were found in the middle parts of the fjords.

According to Rounsefell (1930), Hubbs, in 1925, investigated

racial and seasonal variation in vertebral numbers of the Pacific herring and found an increase in mean vertebral count northwards along the coast of North America. Rounsefell (1930) distinguished numerous separate populations of herring in Alaskan waters on the basis of meristic counts and body proportions. Rounsefell and Dahlgren (1932) found a negative correlation between mean vertebral counts in herring and air temperatures during the period of spawning and development in Prince William Sound, Alaska. Tester (1937a) found negative correlations between the mean vertebral counts of British Columbia herring and air temperatures during spawning at Jap Inlet. In herring, the number of vertebrae is fewer in fish developing in warm water than in those developing in cold water. Some species, however, show an increase in meristic characters when developing in a warmer environment (Cox, 1923). Mottley (1937), Gabriel (1944), and Tåning (1952) have shown experimentally the dependence of vertebral count on temperature during development. According to Blaxter (1958), Svärdson, in 1950, and 1952, by transplantation experiments found that scale counts in whitefish (*Coregonus*) were higher among fish developed at low temperatures.

The body proportions of a fish show changes with growth. Martin (1949) showed that body proportions of fishes are largely influenced by the size of the part at growth inflection, as well as the direction and degree of inflection.

During the late 1920's, sharp differences of opinion separated

those who regarded racial formation as the result of chance hereditary combinations and those who advocated physical and chemical factors acting upon the organisms concerned. Because of mounting evidence, fisheries biologists eventually came to agree that the characters by which races of fishes were identified were definitely under the influence of external environmental factors (Dymond, 1948). Gabriel (1944) developed the theory that temperature affects the relations between the processes controlling growth and differentiation so that low temperatures retard differentiation relatively more than growth. At low temperatures, for example, a greater amount of presumptive myotome tissue would be developed before segmentation, thus greater size would be accompanied by more vertebrae.

Meristic characters are partly controlled by environmental factors during early development and growth, but the mechanics are not understood. It is possible that while meristic counts are partly determined by the environment, the range of variation over which the environment may operate is genetically fixed, but differs from area to area within the range of distribution of a species (Lindsey, 1953). The exact causes of variation in meristic characters in herring will not be discovered until herring can be reared in the laboratory in reasonable numbers (Blaxter, 1958).

RACIAL INVESTIGATION IN *Clupea* FROM CANADIAN WATERS

Tester (1937a) distinguished local populations of herring (*Clupea pallasii* (*sic*)) in the coastal waters of British Columbia using the following characters: total vertebral count, abdominal vertebral count, keeled scale count, sex ratio, rate of growth, head length, and length to insertion of the dorsal fin.

Jean (1945) made a comparative study of herring (*Clupea harengus*) from the estuary and Gulf of St. Lawrence and found three characteristic populations separated by differences in meristic characters and body proportions.

Tibbo (1956) identified four separate and distinct Newfoundland populations of herring (*Clupea harengus*) distinguished by differences in growth, "diameter" of the scales at the end of the first year, mean vertebral counts, and also by length, age, and year class composition of the spawning aggregations.

This is the first investigation on the *Clupea* of Arctic Canada.

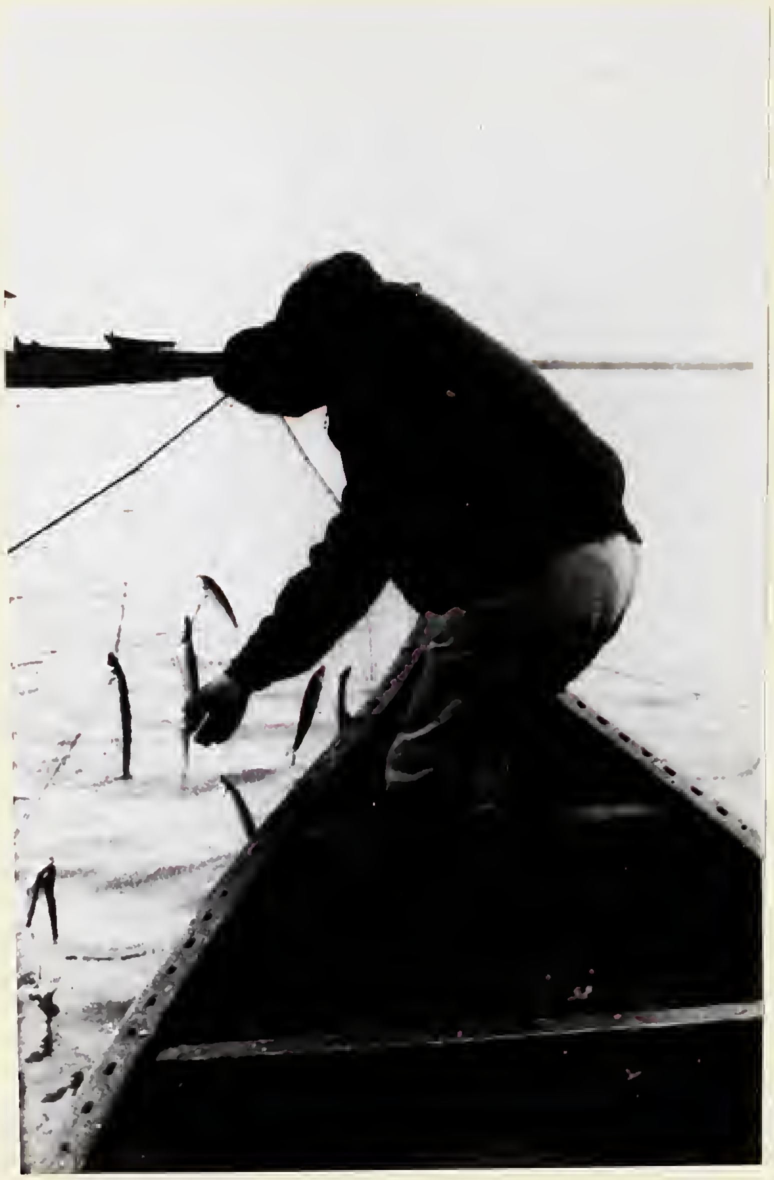

Fig. 8. Removing fish from one and one-half inch gill net at Tuk, September, 1958.

MATERIALS AND METHODS

This study is based on the author's examination of 457 herring, 209 from the Pacific Ocean, and 248 from the Arctic Ocean of Canada. Two hundred and eleven herring were obtained from gill nets at Tuk, N. W. T., from August 31 to September 10, 1958, while the author was employed in field investigations by the Arctic Unit of the Fisheries Research Board of Canada. Seventy-four of the specimens were caught in a 50 yard nylon net of one and one-half inch stretched mesh (Fig. 8). One hundred and thirty-seven specimens were caught in two and one-half, three, and three and one-half inch mesh nets set by Eskimos.

Herring from the Canadian Arctic were borrowed from the collections of the National Museum of Canada (one specimen), the Royal Ontario Museum (13 specimens), and the Arctic Unit of the Fisheries Research Board of Canada (23 specimens).

One hundred and ninety-seven Pacific herring were obtained, through the Biological Station at Nanaimo, B. C., from Walker Rock in the Lower East Coast Sub-district of British Columbia. The specimens were purse seined at Walker Rock, in Trincomali Channel south of Porlier Pass on December 3, 1958.

The Fisheries Institute of the University of British Columbia made available 12 herring netted at the entrance to Kitoi Bay, Afognak Island, Alaska, on June 4 and 5, 1958.

The herring from Tuk and Walker Rock were first preserved in a 10 percent solution of formalin and later transferred to 50

percent isopropyl alcohol for storage and subsequent examination. No information was obtained on the methods of preservation of the other specimens, but they were probably fixed in formalin.

Table I gives a list of the samples, dates, localities, and the methods of capture of the herring used in this study. Collection and museum numbers of the herring used in this study accompany the raw data in Appendix D.

Table I. List of samples, dates, localities, and methods of capture.

Date	Area	Locality	No. of fish	Method of capture
December 3, 1958	North Pacific Ocean	Walker Rock in Trincomali Channel Southern B. C.	197	Seine
June 4 and 5, 1958	North Pacific Ocean	Entrance to Kitoi Bay, Afognak Is., Alaska	12	Gill nets
August 31 to September 10, 1958	Beaufort Sea	Tuktoyaktuk, N. W. T.	211	Gill nets
August 26, 1955	Beaufort Sea	Second finger of Husky Lakes, N.W.T.	22	Gill nets
1916	Beaufort Sea	Cape Bathurst N.W.T.	1	Gill net
August 24, 1937	Beaufort Sea	Tuktoyaktuk, N.W.T.	1	Gill net
September 3 and 4, 1938	Beaufort Sea	Six miles north of Kidluit at mouth of Mackenzie River, N.W.T.	5	Gill nets
August 1 to 14, 1950	Coronation Gulf	Bathurst Inlet, N. W. T.	2	Gill nets
September 13 and 21, 1951	Beaufort Sea	Tuktoyaktuk, N.W.T.	4	Gill nets and beach seine
September 13 and 21, 1951	Beaufort Sea	Yukon	1	Gill net or beach seine ?
August 6, 1955	Beaufort Sea	Tuktoyaktuk, N.W.T.	1	Gill net

The terms and methods of counting and measuring used in this study are given below.

1. Counts:

Lateral line scales (Scales L.)--the number of scales along the mid-lateral scale row from the opercular opening to the base of the caudal fin.

"Keel" scales (Scales K.)--the number of scales, the ventral borders of which edge the keel of the abdomen between the base of the pelvic fins and the anus (Fig. 26). These were used rather than keeled scales, which are the ~~number of~~ scales, with a definite keel, along the ventral midline between the base of the pelvic fin and the anus, because the number of posterior keeled scales is often difficult to determine.

Dorsal scales (Scales D.)--the number of scales from the dorsal fin origin, counting postero-ventrally along the natural scale row to but not including the lateral line scale.

Ventral scales (Scales V.)--the number of scales from the anal fin origin, counting along the natural scale row antero-dorsally to but not including the lateral line scale.

Dorsal fin rays (D. Fin)--the total number of fin rays in the dorsal fin.

Anal fin rays (A. Fin)--the total number of fin rays in the anal fin.

Pectoral fin rays (Pt. Fin)--the total number of fin rays in both pectoral fins.

Pelvic fin rays (Pl. Fin)--the total number of fin rays in both pelvic fins.

Gill rakers (G. Ra.)--the total number of gill rakers on the left first gill arch.

Branchiostegals (Br.)--the total number of branchiostegal rays in both branchiostegal membranes.

Total vertebrae (Total V.)--the total number of vertebrae but not including the basioccipital and hypural (Fig. 19).

Abdominal vertebrae (A. V.)--the number of vertebrae between the basioccipital and the first closed haemal arch.

Caudal vertebrae (C. V.)--the number of vertebrae from the first closed haemal arch to the ~~hypural~~ urostyle.

Herring were x-rayed using Kodak Blue Brand Medical X-ray Film. All vertebral counts were made twice. Specimens with abnormalities such as fused centra and extra spines were not included in the calculations.

2. Measurements

All lineal measurements were made using a measuring board with a meter stick flush with the surface upon which the fish were placed. Fork lengths were read directly from the board. Actual measurements of the head proportions were made using

calipers, the points of which were then placed on the meter scale. Head proportions used include structures of bony nature which presumably shrink very little or not at all with preservation. Measurements were made to the nearest millimeter in most cases, but several 0.5 millimeter data are included. Data were gathered from the left side of each fish except where physical damage necessitated use of the right side. The following characters were measured:

Fork length (F. L.)--the distance between the most anterior part of the head, tip of lower jaw with mouth closed, and the fork of the caudal fin.

Head length (H. L.)--the greatest distance between the most anterior part of the lower jaw, mouth closed, and the most posterior edge of the operculum. The opercular membrane was not included.

Upper jaw (u. j.)--the distance from the most anterior point of the premaxillary to the most posterior point of the maxillary.

Snout (m.)--the distance from the most anterior part of the snout to the anterior bony rim of the orbit. To bring the calipers into contact with the bony rim, slight pressure was exerted on the fleshy lining of the rim.

Postorbital length (p. o.)--the distance from the posterior margin of the bony orbital rim to the farthest posterior edge

of the bony opercular margin.

Eye diameter (e. d.)-- the greatest antero-posterior distance between the bony orbital rims of the eye.

Interorbital width (i)--the width between the dorsal orbital rims immediately above the centers of the pupils.

Not all counts and measurements were obtained from each herring because structures were sometimes damaged or malformed. Only 164 herring were x-rayed to provide the vertebral data for Walker Rock. These factors explain the existing differences in the numbers of fish used in the analyses of the various characters.

Scales were taken from the right side of the fish in the area between the dorsal fin and the mid-lateral scale row. The scales were removed with a scalpel, placed between the pages of a small notebook, and held in place by their mucus.

Before examination scales were removed from the notebook and placed in water for 24 hours to separate them from one another and to soften the mucus and epidermis covering them. Then both sides of the scales were cleaned by rubbing each scale between the forefinger and blotting paper. Ten scales from each fish were placed dry between glass slides. The glass alides were taped together and numbered.

Scales were examined to determine age and "diameter" at the end of the first year using a Reichert Lanameter, with a metric screen rule, enlarging 45 times. Difficulty was encountered in

aging the herring scales because of the presence of transverse lines crossing the scales from side to side. The light intensity was frequently adjusted as necessary to provide maximum contrast to show the rather indistinct annular rings. Scales from herring to the age of six years were easily read, but with increasing age, determinations became more difficult. Ambiguity was caused by annuli in very close proximity to one another at the margins, and by the transverse lines described above. Latinucleate (regenerated) scales with irregular central areas of granular appearance were frequently present. These scales, useless for age determination, were found more frequently among older fish.

Tester (1937b) found the scales from northern British Columbia resembled those from Alaska in that they were more clearly marked and more easily read than those from southern British Columbia. The author could age only 70 percent of the Tuk and 60 percent of the Walker Rock herring. The scales of 80 Tuk herring over the age of six years were re-read to increase the reliability of the data. Three scales agreeing in age of the 10 per slide was the criterion for determining age; however, most slides had more scales, from five to eight, in age agreement despite the presence of regenerated, damaged, or improperly cleaned scales.

Other details of materials and methods will be described in context.

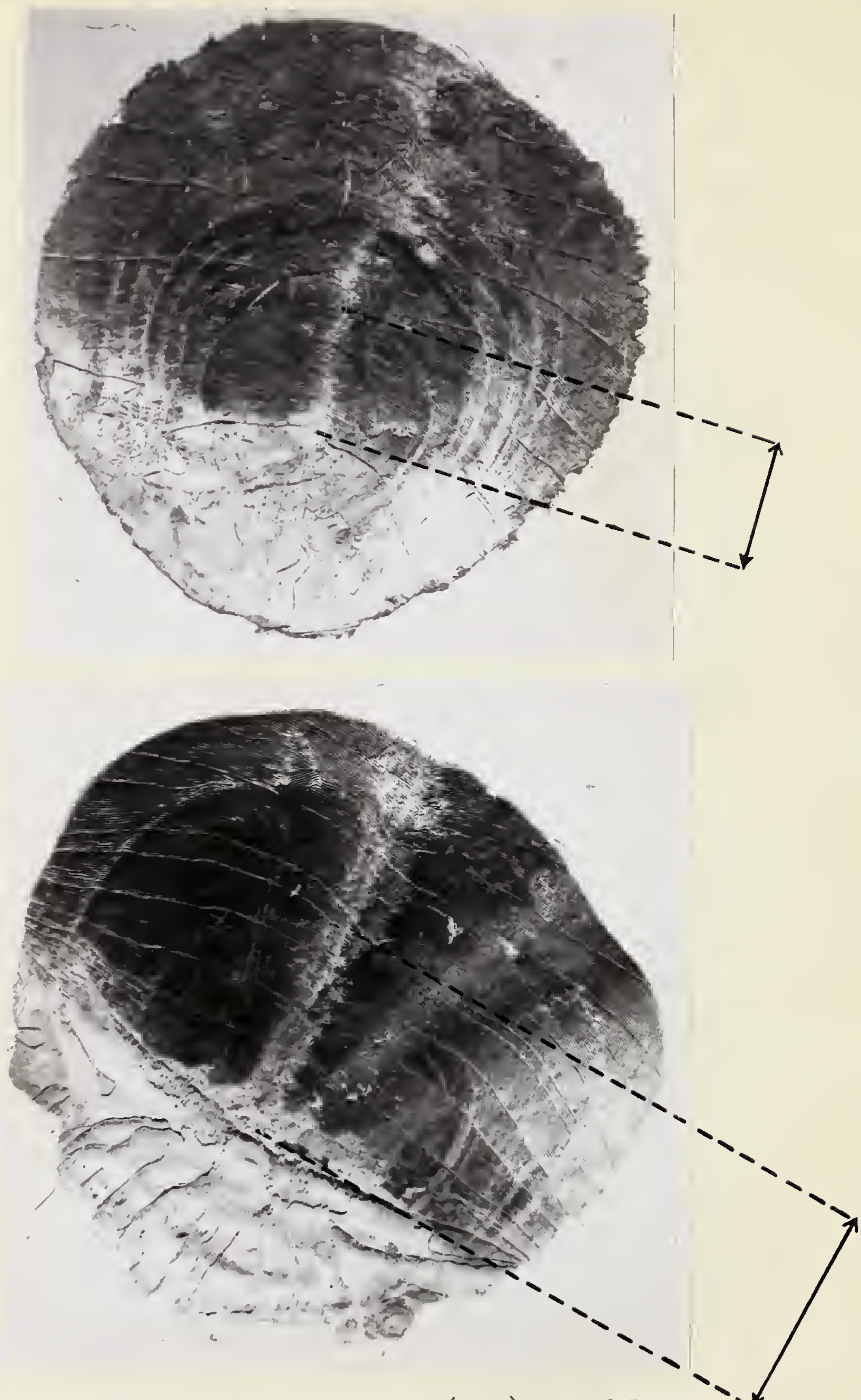

Fig. 9. Herring scales from Tuk (top) and Walker Rock (bottom) showing "diameters" measured.

AGE AND GROWTH

"Diameter" of scales at end of first year

According to Tibbo (1956), Hodgson in 1934 showed that variations do occur in the amount of scale growth in herring during the first year in different localities. In the North Sea herring, the summer- and fall-spawned fish do not have sufficient scale development to record the retardation of growth during the first winter but this condition does not hold true for spring-spawned herring. Tibbo (1956) working on Newfoundland herring concluded that it was possible to distinguish different populations by the "diameter" of the scale at the end of the first year. In the present study, the scale "diameter" at the end of the first year is similar to that used by Tibbo (1956).

The herring of southern British Columbia spawn from the end of February to April while those of Alaska spawn in May and early June. The author assumes that the herring of Tuk and Husky Lakes spawn in early July after breakup and some warming of the water has occurred. These spring breeding fish presumably develop scales sufficiently for a growth check to appear in the first winter.

The first year "diameters" of five to 23 scales from fish of the various ages represented were examined and measured. Figure 9 shows the "diameter" measured. The mean for each age was calculated and the results are given in Table II and represented in Figure 10.

Table II. "Diameter" of scales (mm.) at end of first year for the four localities investigated. Number of scales in parentheses.

Age in years	2	3	4	5	6	7	8	9	10	11	12	13	14	Mean
Walker Rock	1.69 (17)	1.61 (17)	1.66 (15)	1.64 (18)	1.61 (23)	1.70 (20)								1.65 (110)
Afognak Is.			1.27 (9)	1.27 (35)	1.32 (7)	1.28 (7)		1.32 (5)						1.29 (63)
Tuk		1.00 (1)	1.13 (15)	1.18 (15)	1.14 (8)	1.10 (19)	1.24 (19)	1.05 (14)	1.15 (14)	1.19 (15)	1.15 (21)	1.21 (23)	1.23 (6)	1.15 (170)
Husky Lakes						1.13 (6)		1.04 (6)			1.20 (3)	1.12 (7)		1.12 (22)

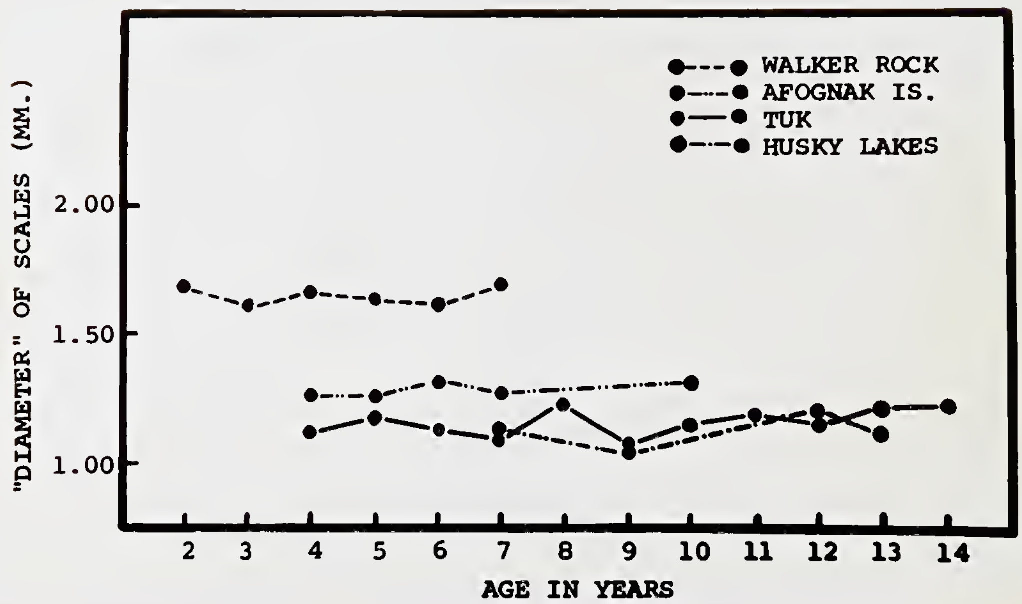

Fig. 10. Scale "diameters" at end of first year for the four localities investigated.

The Husky Lakes and Tuk herring have the smallest first year "diameters" with means of 1.12 millimeters and 1.15 millimeters respectively. Afognak Island herring have a mean of 1.29 millimeters and those from Walker Rock a mean of 1.65 millimeters. The curves for Walker Rock and Afognak Island are distinct from each other as are they both from Tuk and Husky Lakes. T-tests showed significant differences, at one percent probability, between first year scale "diameter" means of Walker Rock and Afognak Island, Walker Rock and Tuk, Walker Rock and Husky Lakes, Afognak Island and Tuk, and Afognak Island and Husky Lakes. No significant difference was present between Tuk and Husky Lakes. The Tuk and Husky Lakes curves overlap and their means differ by 0.03 millimeters. The smaller first year "diameter" means of the Arctic herring probably reflect the shorter summer growing season in Arctic waters. Age group variations in the first year "diameters" range from 0.23 millimeters among Tuk herring to 0.09 millimeters among Walker Rock herring. These differences may reflect varying annual environmental conditions acting upon the physiological processes of the fish. The differences in the "diameters" of the scales, among the four localities, could be caused by variations in temperature and amount of food present during the growing season, as well as the length of the growing season itself. The first year "diameter" variation, among age groups, is greater among Arctic than among Pacific herring.

The smaller first year "diameter" variation among Walker Rock herring may reflect more stable annual environmental conditions in that area than at Tuk, during the time following hatching until the appearance of the first growth check. The scales of Afognak Island herring showed little "diameter" variation among age groups and because of the lack of adequate number of ages represented as well as numbers of scales in each age group, no conclusions on annual variation will be attempted.

Data overlap from the Tuk and Husky Lakes samples which were taken from localities of similar latitude about 45 miles apart, separated by the long projection of the mainland which terminates at Cape Dalhousie.

First year "diameters" of 15 scales from three Bathurst Inlet herring had a mean of 1.05 millimeters. The data from the three Arctic localities showed consistently lower first year "diameters" than those of herring from the Pacific.

Rates of growth

Tester (1937a) found that over several years samples from a single population of British Columbia herring could vary significantly in both length and age composition. Since differences between samples were present, even though selection involved in the use of the beach and purse seine was small, Tester advocated the examination of several samples from each population each year to obtain reliable data for comparative purposes. In the present study, however, only one sample of herring was used from each of the localities studied. The Tuk herring were caught in gill nets, as were the herring from Afognak Island and Husky Lakes. The Walker Rock sample was purse-seined. This study makes a comparison mainly of the Walker Rock and Tuk herring, supplemented with additional data from the small samples from Afognak Island and Husky Lakes.

The Tuk herring were weighed and measured fresh in the field and then preserved in 10 percent formalin. The Walker Rock sample was also preserved in 10 percent formalin at the time of capture. The amounts of shrinkage in fork length and loss of weight, because of preservation, were calculated for the Tuk herring. These corrections were also applied to the Walker Rock herring. Corrections in fork length were also made to the samples from Afognak Island and Husky Lakes. No correction for loss of weight was attempted for Afognak Island and Husky Lakes because of the long periods of time of preservation. Herring tend to lose considerable oil to

the preserving medium. This is difficult to correct for. Corrections applied for shrinkage in fork length, based on the Tuk measurements before and after preservation, are given below. If the fish is:

1. less than 180 mm.--add 4 mm.
2. 180 to 250 mm.--add 5 mm.
3. 251 to 275 mm.--add 6 mm.
4. 276 to 300 mm.--add 7 mm.

Corrections applied to preserved herring for loss of weight, based on Tuk herring, are given below. If the fish weighs:

1. 40 to 49 grams--add 12 grams
2. 50 to 59 grams--add 13 grams
3. 60 to 69 grams--add 15 grams
4. 70 to 79 grams--add 16 grams
5. 80 to 89 grams--add 17 grams
6. 90 to 99 grams--add 18 grams
7. 100 to 109 grams--add 19 grams.

Fork length and weight data as used in the study are as follows:

1. Tuk--fresh weight and fresh fork length
2. Walker Rock--corrected weight and corrected fork length
3. Afognak Island--preserved weight and corrected fork length
4. Husky Lakes--preserved weight and corrected fork length
5. other specimens--preserved weight and corrected fork length.

Table III gives the mean lengths and weights for each age group in the samples from Walker Rock, Afognak Island, Tuk, and Husky Lakes.

Table III. Mean fork lengths and weights for each age group (sexes combined) in samples from Walker Rock, Afognak Is., Tuk, and Husky Lakes. Numbers of fish in parentheses.

Age	2	3	4	5	6	7	8	9	10	11	12	13	14
						Fork length in mm.							
Walker Rock	173.8 (8)	196.9 (15)	201.4 (26)	206.1 (24)	207.1 (30)	202.0 (4)							
Afognak Is.			207.0 (1)	220.0 (7)	244.0 (1)	261.5 (2)			287.0 (1)				
Tuk		186.0 (3)	197.3 (54)	207.4 (7)	260.4 (5)	272.3 (6)	273.1 (7)	303.7 (11)	310.2 (11)	315.8 (9)	317.2 (17)	324.2 (15)	331.0 (2)
Husky Lakes				248.0 (1)		244.5 (6)	236.0 (1)	262.3 (7)		276.0 (2)		280.0 (2)	
						Weight in gm.							
Walker Rock	61.38 (8)	91.13 (15)	93.65 (26)	101.21 (24)	100.63 (30)	98.25 (4)							
Afognak Is.			76.00 (1)	113.14 (7)	131.00 (1)	194.00 (2)		245.00 (1)					
Tuk		64.33 (3)	84.11 (54)	100.86 (7)	251.40 (5)	275.00 (6)	292.85 (7)	363.18 (11)	393.91 (11)	419.44 (9)	416.47 (17)	454.33 (15)	517.50 (2)
Husky Lakes				142.00 (1)		142.83 (6)	127.00 (1)	169.28 (7)		214.00 (2)		235.00 (2)	

Since only 60 and 70 percent of the herring from Walker Rock and Tuk, respectively, were definitely aged, an age group with proportionately fewer fish might tend to have less reliable fork length and weight means.

The Tuk herring were caught in nets of one and one-half, two and one-half, three, and three and one-half inch stretched mesh sizes. The selectivity of the nets for fish of certain sizes resulted in a tri-modal length frequency distribution for the sample with modes around 190, 270, and 310 millimeters. There is a large interval of 53.4 millimeters in mean fork length between ages five and six because of net selectivity. The one and one-half inch net tended to catch the smaller of the five-year-old, whereas the two and one-half inch net tended to catch the larger of the six-year-old herring. A smaller interval of 30.6 millimeters in mean fork length exists between the ages of eight and nine. Here the two and one-half inch net selected for the smaller eight-year-old and the three and one-half inch net selected for the larger of the nine-year-old herring. A small number of herring were obtained from Eskimo three inch nets and these fish make the data for nine-year-olds slightly more reliable than if fish from only the three and one-half inch mesh had been used. Fork lengths and weights for age 14 may be slightly below their value in the natural population because the three and one-half inch net probably selected for the smaller

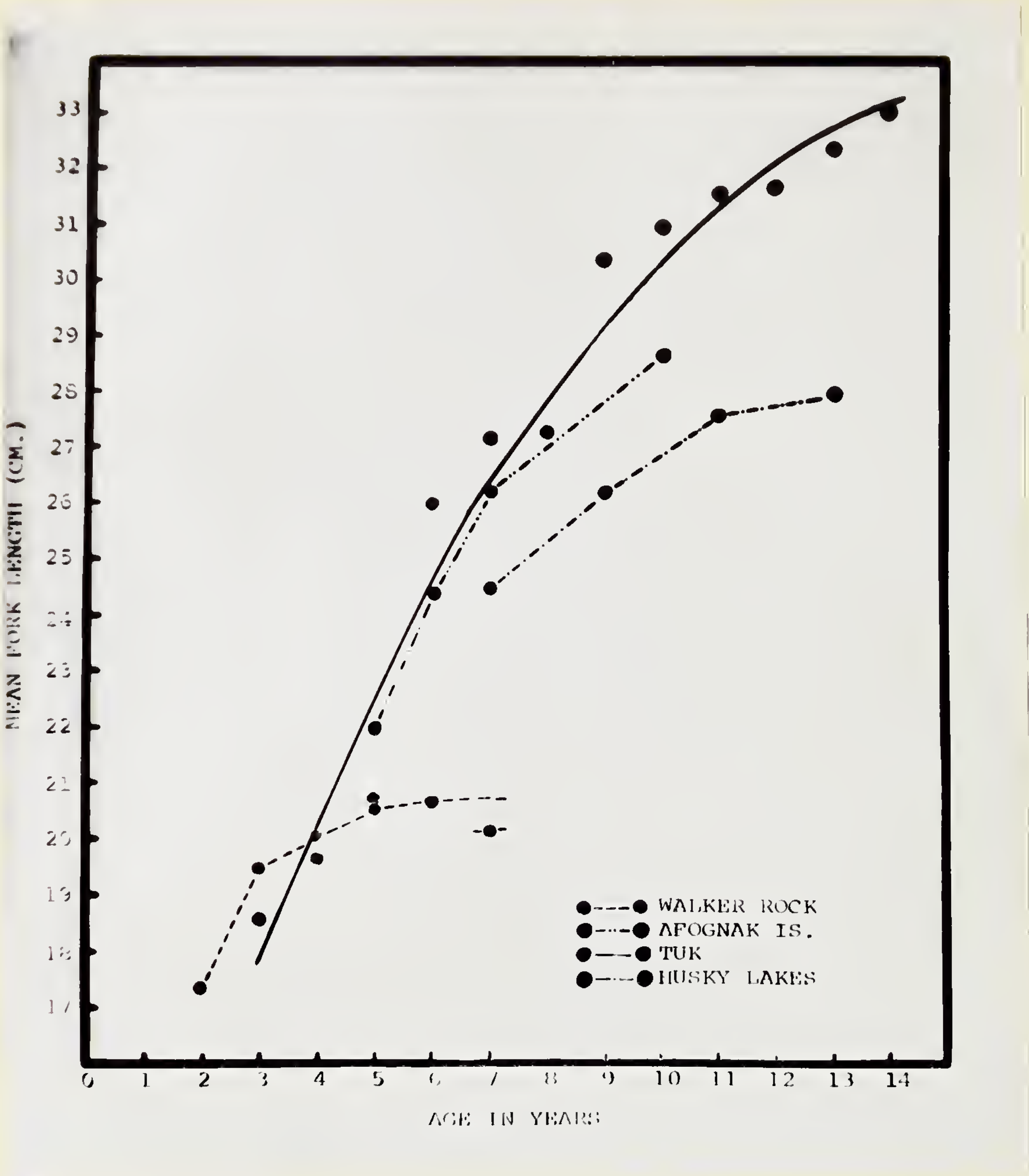

Fig. 11. Rates of growth of herring (sexes combined) for the four localities investigated.

herring of this age.

The weights for the Tuk herring in the various age groups show a similar pattern of variation as fork length because of the selectivity of the gill nets.

A fish shows indeterminate growth as it increases in size and in old age very slowly nears its ultimate growth. The rate of growth is directly affected by temperature and influenced greatly by annual fluctuations in food conditions. Rounsefell (1930) found differences in growth rates valuable in distinguishing local populations of Alaska herring.

Figure 11 represents graphically the growth rates (sexes combined) for the four localities investigated. The herring from Walker Rock are small, ranging in length from 160 to 230 millimeters. Tester (1937a) found a similar length distribution for the herring of southern British Columbia but stated that more northern populations achieved greater length and age. The growth curves show that at age seven, fork length is greatest at Tuk, slightly less at Afognak Island, still less at Husky Lakes, and least at Walker Rock. Herring from Tuk appear to grow at a slower rate during early life to age four but then surpass Walker Rock at five years and continue to increase rapidly in length to about age 10. Two unusually large intervals in mean fork length of Tuk herring between ages five and six, and between ages eight and nine are chiefly a result of sampling with gill nets which

select fish of only certain sizes, as discussed above. The Walker Rock herring grow rapidly in length until age four after which the growth rate quickly tapers off, the herring reaching maximum growth around ages six and seven. The low mean fork length for Walker Rock at age seven does not give a true picture because the sample contained only two fish, both probably slightly below average length for this age. Rounsefell (1930) found separate populations of Alaskan herring with growth rates very similar to both Tuk and Walker Rock. In his studies, a more northern population, from southeast Alaska, showed a Walker Rock-like growth rate whereas a more southern population, from Unalaska, showed a Tuk-like growth rate. The above mentioned population growth curve from southeast Alaska was not representative of the whole area, the herring coming from a locality of enclosed water. The Tuk and Husky Lakes populations differ considerably in their growth rates with the Tuk herring having a larger mean fork length by 27.8 millimeters at age seven and 44.2 millimeters at age 13. The sample from the Husky Lakes was collected in brackish water about 60 miles inland from the Beaufort Sea and approximately 45 miles due east of Tuk. The herring from Tuk were collected in a bay within several hundred yards of the open sea (brackish water). Among European herring, those of the Baltic and White Seas also show a slower growth rate in the enclosed waters of each general area (Rounsefell,

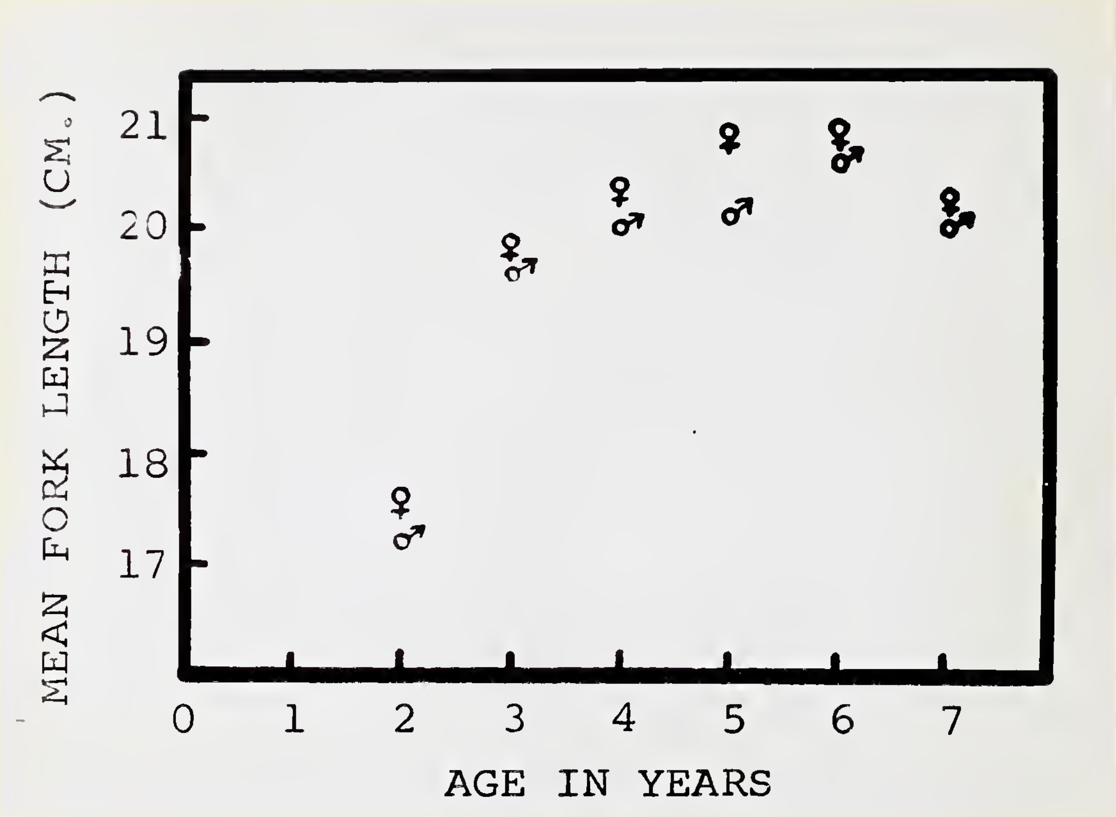

Fig. 12. Growth in fork length of male and female herring from Walker Rock.

1930). The different growth rates in the various waters may be caused by differences in amounts of food available as well as variations in salinity and temperature.

In British Columbia herring, females show a faster growth rate than males (Tester, 1937a). Atlantic herring differ in this respect from Pacific herring since both Jean (1945) and Tibbo (1956) were unable to demonstrate differences between the mean lengths of males and females for the same ages from the Gulf of St. Lawrence and Newfoundland respectively. Table IV gives the average fork lengths of males and females in each age group in samples from the four localities investigated. The Walker Rock females tend to be slightly longer than the males for the ages two to seven represented in the sample (Fig. 12). The differences in fork length between the sexes are nearly constant throughout the whole growth curve of the sample studied and vary from two to seven millimeters.

Figure 13 shows the rates of growth of males and females from Tuk. This Arctic population also shows that the females tend to be slightly longer than the males. The differences between the mean fork lengths of the sexes vary from 0.4 to 18.6 millimeters. In the Tuk sample, the males have a greater fork length mean than the females only at ages six and 11 and it is possible that if more specimens than five and nine (number of fish in each age group) had been used the higher

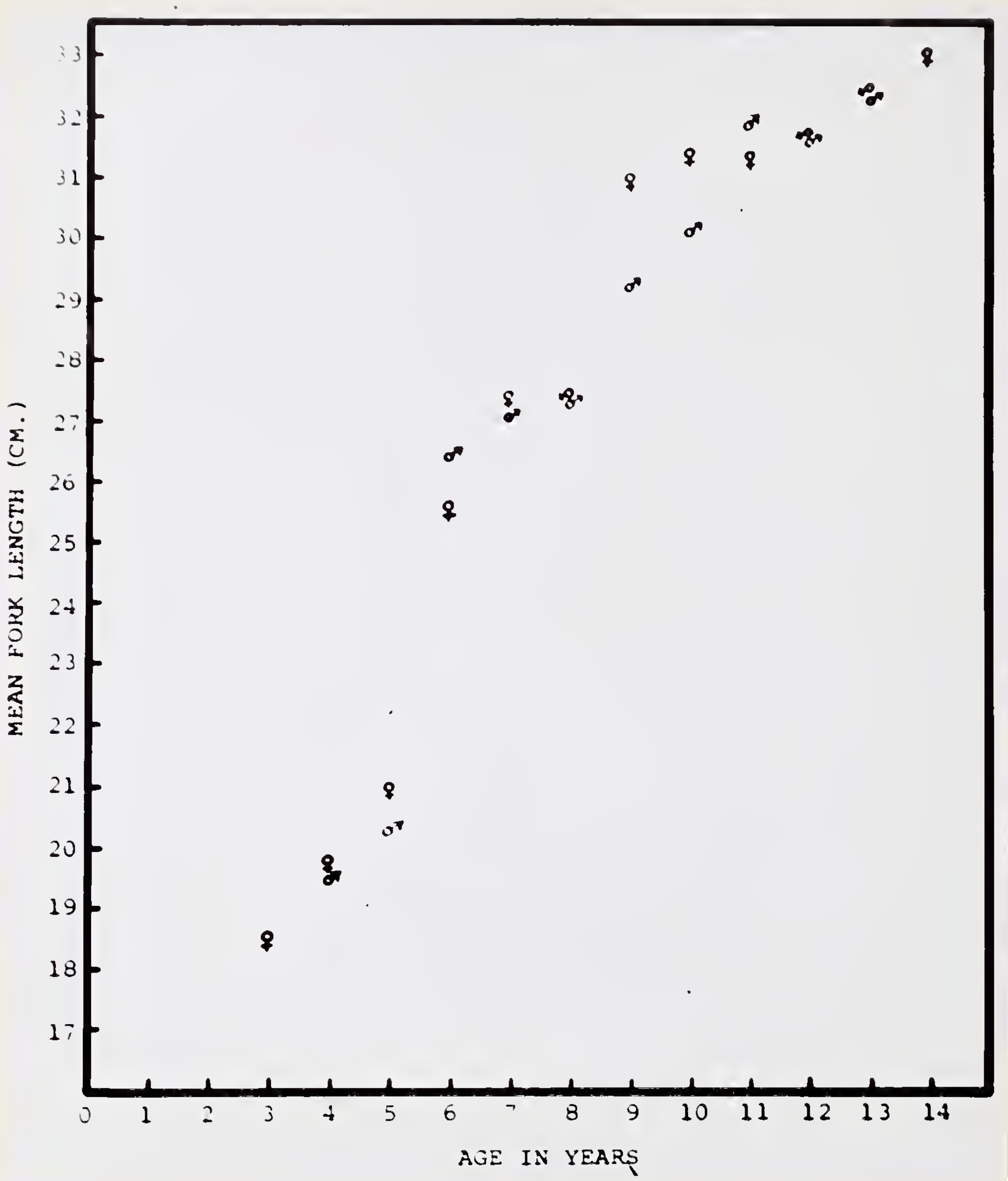

Fig. 13. Growth in fork length of male and female herring from Tuk.

Table IV. Mean fork lengths of males and females for each age group in samples from Walker Rock, Afognak Is., Tuk, and Husky Lakes. Numbers of fish in parentheses.

Age		2	3	4	5	6	7	8	9	10	11	12	13	14
Walker Rock	♂	171.8 (4)	195.5 (8)	199.5 (14)	201.4 (8)	205.7 (16)	203.0 (1)							
	♀	175.8 (4)	198.6 (7)	203.5 (12)	208.4 (16)	208.7 (14)	200.3 (3)							
Afognak Is.	♂			207.0 (1)	212.0 (3)	244.0 (1)	247.0 (1)							
	♀				226.0 (4)		276.0 (1)			287.0 (1)				
Tuk	♂			195.3 (19)	203.3 (3)	263.3 (3)	271.0 (3)	273.1 (5)	291.8 (4)	301.0 (3)	319.3 (3)	315.7 (3)	323.2 (4)	
	♀		186.0 (3)	198.4 (35)	209.8 (4)	256.0 (2)	273.7 (3)	273.5 (2)	310.4 (7)	313.6 (8)	314.0 (6)	317.5 (14)	324.6 (11)	331.0 (2)
Husky Lakes	♂				248.0 (1)		246.0 (5)	236.0 (1)	259.5 (4)		280.0 (1)		280.0 (2)	
	♀						237.0 (1)		266.3 (3)		273.0 (1)			

mean would have shifted to favour the females. The Afognak Island and Husky Lakes age groups have in them only very few aged fish of each sex making mean fork length comparisons rather hazardous.

A given increase in the length of a larger fish represents the addition of a much greater amount of tissue, hence weight, than a similar increase in the length of a smaller fish. When comparing weights of a species of fish from different localities, it is necessary to use fish caught at the same season of the year. In herring variations in weight are caused by the state of the development of the gonads and the amount of ister or "belly fat" (fat stored among the viscera in the body cavity) present. Herring are thin and contain little fat after spawning. The gonads of mature male Tuk herring in September weigh approximately 16 percent of the total body weight. It would be unsound procedure to compare weights of these fish with males captured just after spawning. Table III gave the average weights for each age group (sexes combined) in the samples from the four localities investigated. Age-weight comparisons from the four localities will not be made because of the different stages of the development of the gonads, the weights of which affect the total weight of the herring. The Tuk and Husky Lakes herring were caught about two months after spawning, the Walker Rock herring were caught about nine months after spawning, and the Afognak Island herring were caught during the spawning period. Table V gives the mean weights of males and females from each

Table V. Mean weights of males and females for each age group in samples from Walker Rock and Tuk. Numbers of fish in parentheses.

Age		2	3	4	5	6	7	8	9	10	11	12	13	14
Walker Rock	♂	60.25 (4)	90.38 (8)	90.71 (14)	95.25 (8)	97.38 (16)	99.00 (1)							
	♀	62.50 (4)	89.14 (7)	98.07 (12)	104.19 (16)	104.36 (14)	98.00 (3)							
Tuk	♂			81.47 (19)	94.33 (3)	257.33 (3)	285.00 (3)	301.00 (5)	340.00 (4)	372.66 (3)	438.33 (3)	415.00 (3)	455.00 (4)	
	♀		64.33 (3)	85.54 (35)	105.75 (4)	242.50 (2)	265.00 (3)	272.50 (2)	376.43. (7)	401.87 (8)	410.00 (6)	416.78 (14)	454.09 (11)	517.50 (2)

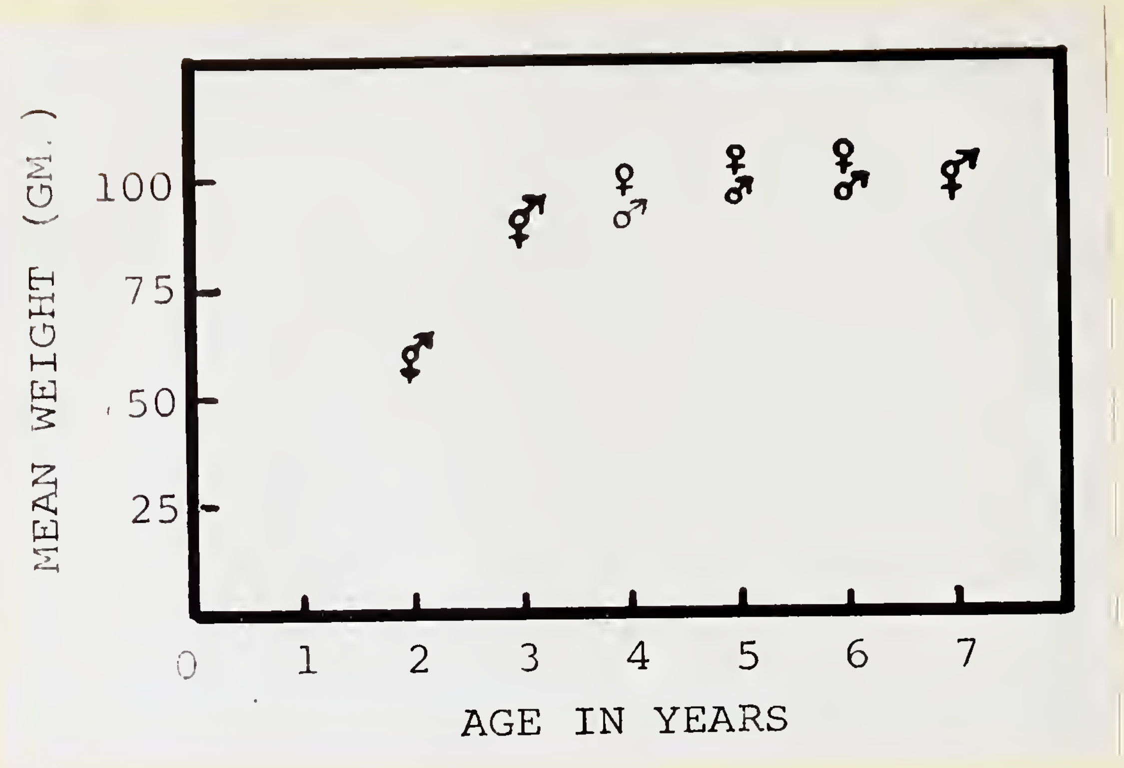

Fig. 14. Growth in weight of male and female herring from Walker Rock.

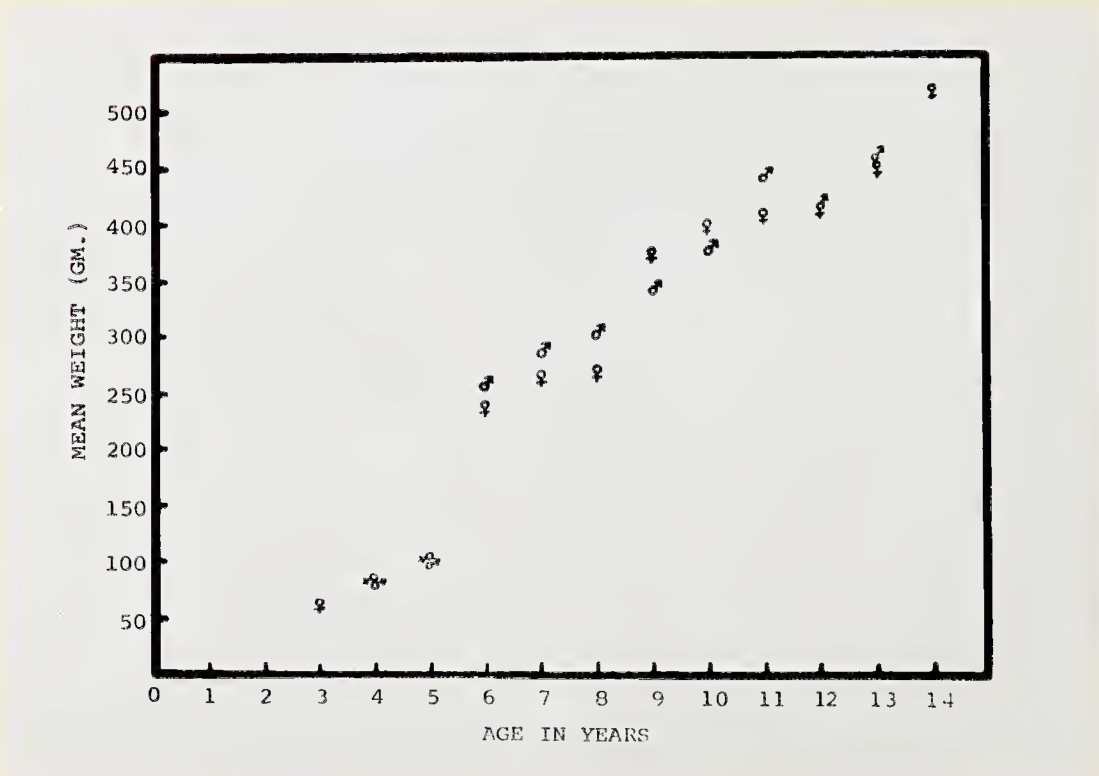

Fig. 15. Growth in weight of male and female herring from Tuk.

age group for Walker Rock and Tuk. Figures 14 and 15 show the growth in weight of males and females from Walker Rock and Tuk.

Most Walker Rock herring are mature at age three and the well-developed gonads of the December sample contribute to the total weight, whereas the Tuk herring do not mature until age six and therefore have very little weight contributed by the gonads up to that age. The increase in weight among Walker Rock herring levels off around age five, whereas herring from the samples of Afognak Island, Tuk, and Husky Lakes continue to gain weight to ages 10, 13, and 14 respectively.

In the sample from Walker Rock, the females tended to be slightly heavier than the males (Fig. 14). In the sample from Tuk, the males and females tended to have similar weights with males outweighing females at some ages and females outweighing males at others (Fig. 15). Unfortunately only few aged fish were available in many of the age groups. This factor plus the selectivity of the gill nets detracts from the reliability of the herring data from Tuk and therefore no conclusions on weight differences between sexes will be attempted.

Figure 16 shows the length-weight relationship for the herring (sexes combined) of Tuk with mean fork lengths per five centimeter groups plotted against weight in grams. The herring increase in weight at a uniform rate to somewhere between 220 and 250 millimeters after which increases in weight are accompanied by progressively smaller increases in fork length.

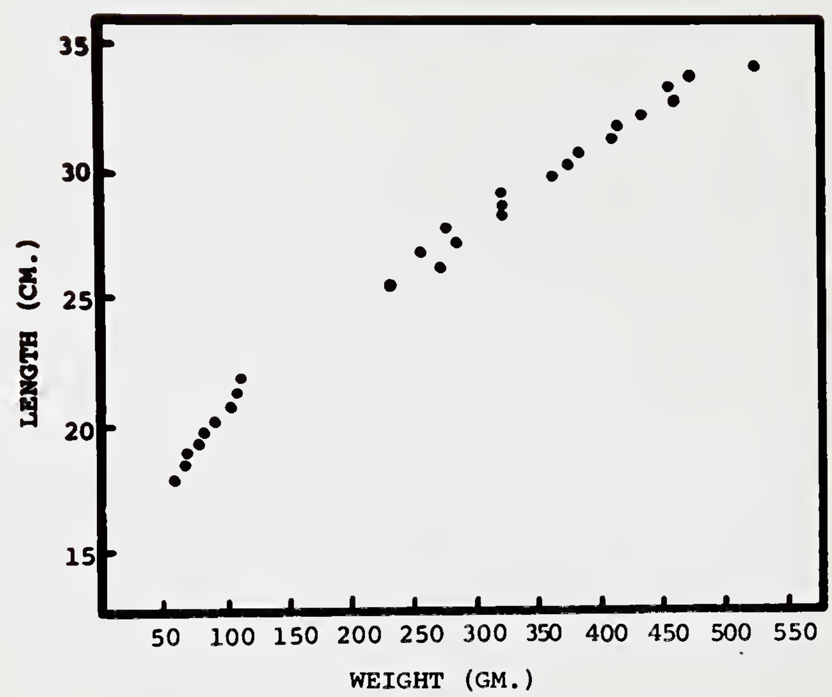

Fig. 16. Length-weight relationship of herring (sexes combined) from Tuk.

The relationship between length and weight of a fish can be represented by the formula $W = kL^3$

where W = weight

k = a constant

and L = length.

A variation of this cube law was used to compare herring of different ages at the same time of the year. The coefficient of condition, K, was determined by the formula $K = 100{,}000\ W/L^3$ (Rounsefell and Everhart, 1953). K was calculated for the herring of each age (sexes combined) from Walker Rock (Fig. 17) and Tuk (Fig. 18). Variations in K can reflect changes in body form, and changes in the amounts of tissue present of density other than that characteristic of the fish as a whole. Changes in the sizes (weights) of the gonads as well as variation in the amount of fat present during the various seasons of the year would be reflected in variations of K in the herring. K for herring from Walker Rock varied from 1.13 to 1.19, with a mean of 1.16, from ages two to seven. The plotted values of K for Walker Rock (Fig. 17) produced an almost straight line which signifies a uniform increase, with age, of weight and length. K for herring from Tuk varied from 0.99 to 1.44, with a mean of 1.32, from ages three to 14. The plotted values of K for Tuk (Fig. 18) occur around a mean of 1.08 for ages three, four, and five. A considerable increase then occurs and from ages six to 14, after which K varies around 1.36.

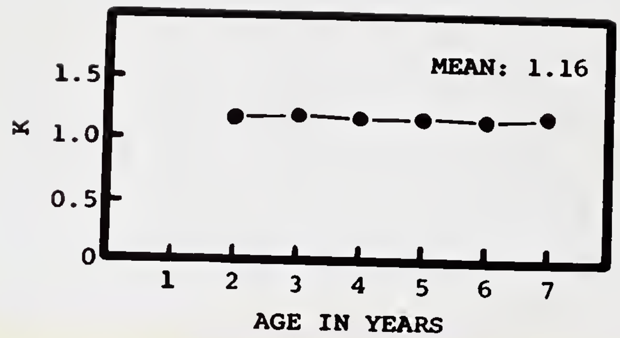

Fig. 17. Coefficient of condition, K, for Walker Rock herring of various ages (December 3, 1958).

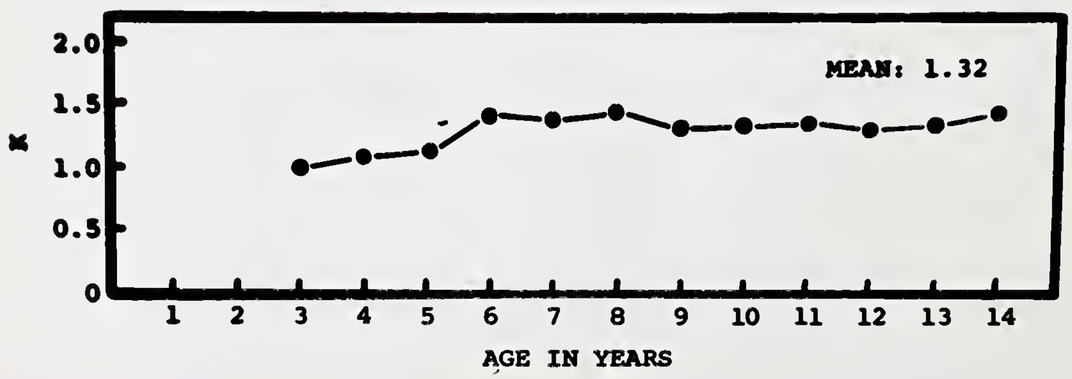

Fig. 18. Coefficient of condition, K, for Tuk herring of various ages (August 31 to September 10, 1958).

The statistically significant increase in K at age six is caused by the herring becoming mature at this age. The gonads, mature and enlarged, add considerable weight to the total weight of the herring from age six on, causing the increased value of K.

The Walker Rock sample shows only a very small increase between ages two and three because most of the two-year-old fish, actually about three months short of three years old, possess well-developed gonads in preparation for spawning in the spring.

Age at maturity

Most southern British Columbia herring mature at age three, whereas those of northern British Columbia and Alaska mature at ages three and four. The later northern maturity is reflected in the commercial fisheries which the herring enter in part at age three but in full force at age four (Tester, 1937b). The bulk of Kamchatka herring reach maturity at ages four and five. The Atlantic herring of the Barents Sea mature at ages five and six, whereas the natios maris-albi and suworowi mature at ages three to four and four to five respectively. The herring from the Beaufort Sea at Tuk were found to be ~~mature~~ maturing at age six. Several males and a female at age five possessed gonads slightly larger and more developed than the rest of their age group, but it is most unlikely that they would have spawned the following spring. Herring at age six were definitely ~~mature~~ prepared to spawn the following spring as indicated by distended testes in the males and developing ova in the ovaries of the females.

TIME OF SPAWNING

From September 8 to 10, 1958, gonads were removed and weighed from 22 freshly caught Tuk herring. Table VI gives the specimen number, sex, fork length, body weight, age, gonad weight, and percentage gonad weight of total weight for seven males and 15 females.

Table VI. Percentage gonad weight of total weight in freshly caught Tuk herring, September 8 to 10, 1958.

Specimen number	Fork length (mm.)	Weight	Age	Gonad weight (gm.)	% of total weight
		Males			
163	299	350	10	53	15.14
172	301	365	-	50	13.70
180	310	400	-	61	15.25
169	313	410	12	70	17.07
184	316	390	13	70	17.94
166	318	410	12	66	16.09
165	329	400	-	63	15.75
					Mean -- 15.85
		Females			
177	305	375	14	22	5.87
168	306	410	12	19	4.63
164	308	375	10	25	6.67
167	312	425	-	26	6.12
200	313	425	-	25	5.88
206	315	395	-	22	5.57
175	315	400	12	22	5.50
182	315	420	14	25	5.95
205	315	420	-	28	6.66
173	316	425	13	28	6.59
170	319	435	12	25	5.75
179	321	400	-	26	6.50
190	323	435	13	27	6.21
181	326	325	12	23	7.08
207	338	475	13	34	7.16
					Mean -- 6.14

The gonad weights of the males varied from 13.70 percent to 17.94 percent of the total weight with the mean of 15.85 percent. The gonad weights of the females varied from 4.63 percent to 7.16 percent of the total weight with the mean of 6.14 percent. Both sexes showed an increase in percentage gonad weight of total weight with increasing fork length.

Whereas the Atlantic herring have both spring and fall spawners, the Pacific herring spawn from December to July. British Columbia herring spawn from late February to April (Tester, 1935). Andriashev (1954) reported Laptev Sea herring ready for breeding in August. The natio suworowi in the Kara Sea spawns during August and the first half of September. The differences in spawning period depend upon geographical situation and the conditions of temperature and ice at the place of spawning.

Gonad development was divided into the following stages based on the size of the gonads in relation to the body cavity, as well as the appearance of the gonads themselves.

1--immature

2--gonads beginning to fill (slightly swollen)

3--gonads approximately one-half full

4--gonads three-quarters full to ripe and running

5--spent.

Table VII gives a list of dates, localities and state of development of the gonads of herring from the Beaufort Sea and Coronation Gulf used in this study.

Table VII. List of dates, localities, and state of development of gonads of herring from the Beaufort Sea and Coronation Gulf. Numbers of fish in parentheses.

Date	Locality	Stage of development of gonads	
		Males	Females
August 1 to 14, 1950	Bathurst Inlet	2 (1)	2 (1)
August 6, 1955	Tuk	2.5 (1)	-
August 24, 1937	Tuk	3 (1)	-
August 26, 1955	Husky Lakes	3 (16)	2.5 (6)
September 3 and 4, 1938	Kidluit	4 (1)	3 (4)
August 31 to September 10, 1958	Tuk	4 (12)	3 (32)
September 13 and 21, 1951	Yukon	4 (1)	-
September 13 and 21, 1951	Tuk	4 (2)	3 (2)

The gonads of the mature Tuk herring caught in early September were quite well developed with most males around three-quarters full to nearly ripe and running. The ovary development at this time, however, was not so advanced with most females around one-half full of small whitish, opaque eggs. The females were definitely not near spawning condition; ~~because~~ ripe eggs of herring are larger, translucent, and have a pale yellowish tinge.

During field investigations at Tuk in September, 1958, the

author gave seven of 34 females stage 4 rating on the assumption that the gonads of both sexes showed parallel development. Closer examination of preserved specimens showed that the females developed more slowly than the males and that most of the females were around stage three while the males were around stage four.

The increasing development of the gonads with the progression of the summer (Table VII) indicates that the herring of the Beaufort Sea and adjacent waters probably spawn in spring, early in July shortly after breakup. Newfoundland herring show a similar gonad development pattern in which males develop earlier than females, both sexes become full and ripe by mid-December, and remain so until depleted by spawning the following May and June (Tibbo, 1956).

SEX RATIOS IN SAMPLES FROM WALKER ROCK AND TUK

The sex ratios of the samples from Tuk and Walker Rock cannot be accurately compared because of the different methods of capture. The purse-seined material from Walker Rock gives a reliable indication of the sex ratio present. Tuk herring were caught with gill nets which have the tendency to select certain sizes of fish. Proportions of the sexes appear in Table VIII.

Table VIII. Proportions of sexes in samples from Walker Rock and Tuk. Numbers of fish in parentheses.

Locality	% males	% females
Tuk (209)	32.5 (68)	67.5 (141)
Walker Rock (197)	54.3 (107)	45.7 (90)

The low ratio of males to females in the Tuk herring is in evidence throughout the whole fork length range of the sample. Among the fish around 300 millimeters long the ratio is approximately 40:60, whereas around 200 millimeters, the ratio is still higher, 30:70. These low male to female ratios definitely indicate a preponderance of females over males in the population of herring at Tuk. In the Walker Rock sample the males predominate over females in a 55:45 ratio. Tester (1937a) found that there are usually more females than males among the populations of British Columbia herring, but that males occasionally predominate

in the younger age groups. Tester also noted a gradual increase in the percentage of females with age. No sex ratios for different ages were calculated in the present study because of the small numbers of aged fish from each locality.

COMPARISONS OF MERISTIC CHARACTERS

In this comparative study of north Pacific and Canadian Arctic herring, it is necessary to use numerous characters for comparisons because only small samples of fish were available from Arctic waters. There are two main kinds of characters used in racial determination of fishes, counts and measurements. Growth rates, spawning habits, and age composition can also be used to distinguish races. Since the Arctic herring samples were not representative, in year class composition, of the natural populations from which they were taken because of the selectivity of the gill nets, age composition was not used. A good character must show a certain amount of variation, such as the vertebrae of herring.

Isolation of groups of organisms, belonging to the same species, results in the development of certain characteristics peculiar to each group. Differences may occur in physical structure or appear as differences in the life history. The changes in characters, brought about by environmental or genetic factors or both, tend to persist and can be used to identify local populations. Certain meristic characters and body proportions of samples from the four localities, Walker Rock, Afognak Island, Tuk, and Husky Lakes were compared to determine what differences exist among the herring from these localities and to see what characters, if any, could be used to distinguish between Pacific and Arctic herring.

Means, standard errors, and standard deviations of the meristic

characters were calculated for each of the samples from Walker Rock, Afognak Island, Tuk, and Husky Lakes. Differences between the means were tested for statistical significance using the t-test (Johnson, 1950). The line between non-significance and significance is taken as 0.01, the one percent level. The null hypothesis, that there is no difference between the means, is rejected if the calculated t exceeds the t value at one percent probability.

1. Vertebrae

A general gradation in vertebral numbers of herring, increasing northward and westward, exists along the west coast of North America with mean vertebral numbers ranging from 50.68 at San Diego Bay, California, to 54.67 at Shumagin Is. near the end of the Alaska Peninsula (Rounsefell, 1930). Tester (1937a) found that British Columbia herring from the southern waters have a lower mean count then those from the northern waters and stated further that the persistence of this gradation demonstrated only slight intermingling among herring of various areas separated by more than 60 nautical miles. The number of vertebrae in the herring is determined before hatching (Gwynn, 1940), and subsequent environmental conditions do not affect the count. Rounsefell and Dahlgren (1932) and Tester (1937a) established negative correlations between the vertebral means and the air

Fig. 19. X-ray showing the vertebral column of a herring from Tuk.

temperatures at which spawning and incubation occur. Similar correlations between water temperatures and vertebrae means have been shown to exist for Atlantic herring (Jean (1945) and Tibbo (1956)). Blaxter (1957) showed experimentally by rearing Atlantic herring eggs at various temperatures that low temperatures resulted in higher myotome numbers than development at higher temperatures. He correlated vertebral numbers directly with myotome counts.

The basioccipital and urostyle ~~hypural bones~~ were not included in the counts. Abdominal and caudal vertebrae were distinguished by the presence of closed haemal arches in the latter (Fig. 19).

The author was unable to determine the vertebral numbers of some herring because of (1) faintness of vertebrae in some long preserved museum specimens (probably inorganic salts had been leached out by acidic formalin), and (2) twisted or curled positions of some specimens. Vertebral columns with fused centra or extra spines were not included in the calculations.

In both Atlantic and Pacific herring, mean vertebral counts of two year classes from the same locality often differ significantly (Tester, 1937a). Since the mean vertebral count varies from year class to year class, the sample mean will be influenced by the proportions of each year class present. Therefore, mean vertebral count comparisons between localities should be confined to one year class, but this was not done in the present study because of the few individuals in each year class among the herring

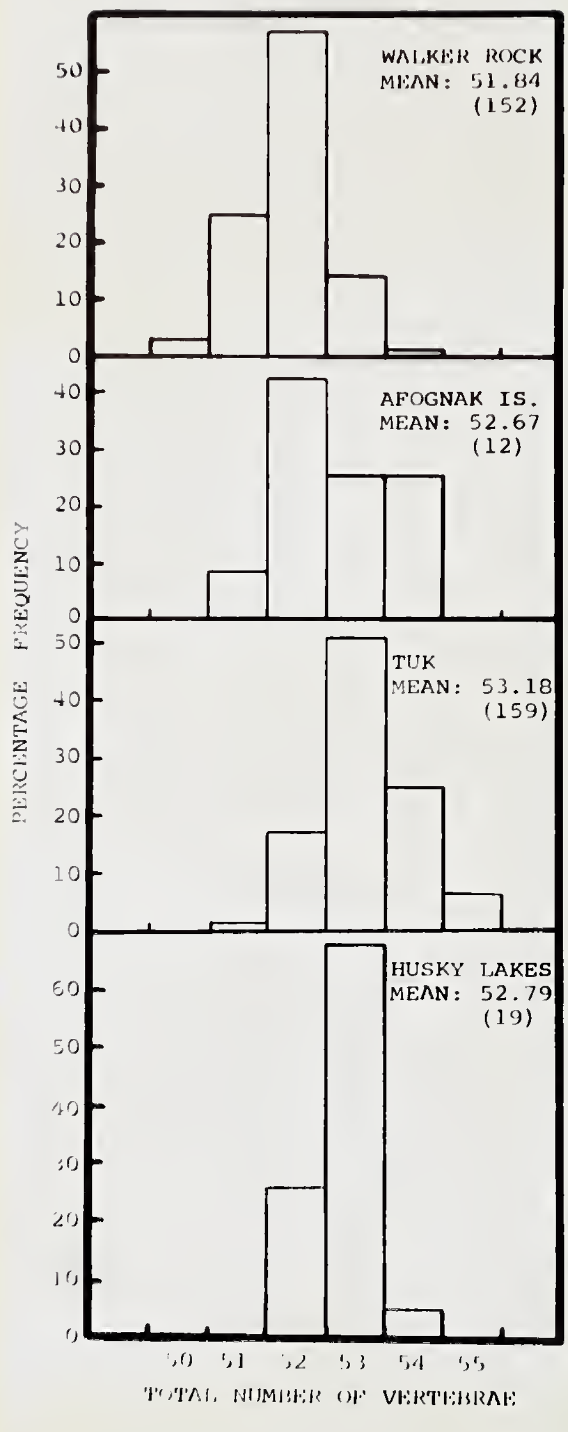

Fig. 20. Total vertebral count distributions for the four localities investigated.

from Afognak Island, Tuk, and Husky Lakes. Instead, sample means were calculated for each area and used for comparative purposes. The author used vertebral data from 152 Walker Rock, 12 Afognak Island, 157 Tuk, and 19 Husky Lakes herring. No statistically significant differences were found between the males and females from either Walker Rock or Tuk. Therefore sexes were not segregated for vertebral number comparisons. Table IX gives the vertebrae means for fish of the four localities investigated and Figure 20 shows the percentage distributions of total numbers of vertebrae.

Table IX. Total vertebral count means for the four localities investigated.

Locality	Number of fish	Mean	S. D.	S. E.	Mean $\pm$ 3 S. D.
Walker Rock	152	51.84	0.72	0.058	49.68 to 54.00
Afognak Is.	12	52.67	0.98	0.283	49.73 to 55.61
Tuk	159	53.18	0.72	0.057	51.08 to 55.28
Husky Lakes	19	52.79	0.52	0.119	51.23 to 54.35

The total vertebral count means of Walker Rock and Tuk differ significantly with the calculated t=16.54 much greater than P=0.01 (2.59). Walker Rock also differs significantly from both Afognak Island (t=7.76, P at 0.01=2.61) and Husky Lakes (t=7.14, P at

0.01=2.61). The Afognak Island mean does not differ significantly from either Tuk (t=1.77, P at 0.05=1.98) or Husky Lakes (t=0.39, P at 0.50=0.68). Tuk and Husky Lakes also show a significant difference (t=2.95, P at 0.01=2.60). The significant differences between Walker Rock and the other three localities, all with higher means from 0.83 to 1.34 vertebrae, probably reflect differences in environmental conditions during development before hatching. The Walker Rock herring probably develop at higher temperatures than do the herring of the other three localities. The significant difference, although small, between the total mean vertebral counts of Tuk and Husky Lakes may be a result of the geographic location of the two localities. Both localities are at the same latitude (69° N) with Tuk (133° W) about 50 miles west from the second finger of the Husky Lakes (131° W).

Presumably the Tuk herring spawn along the coast around Tuk in the numerous small bays and lagoons which have direct contact with the open sea. Liverpool Bay and the Husky Lakes, on the other hand, extend like a narrow, slightly crooked arm about 140 miles inland from the Beaufort Sea. In spring the surrounding mainland is warmed and after breakup the atmosphere, in addition to the rays of the sun, can exert its warming effect on the waters in which the herring spawn. The Tuk coastline is exposed to the open sea which is cold, carries ice, and probably does not warm as rapidly after breakup as the Husky Lakes, and thereby might present a cooler environment to the spawning herring. The cooler water temperature

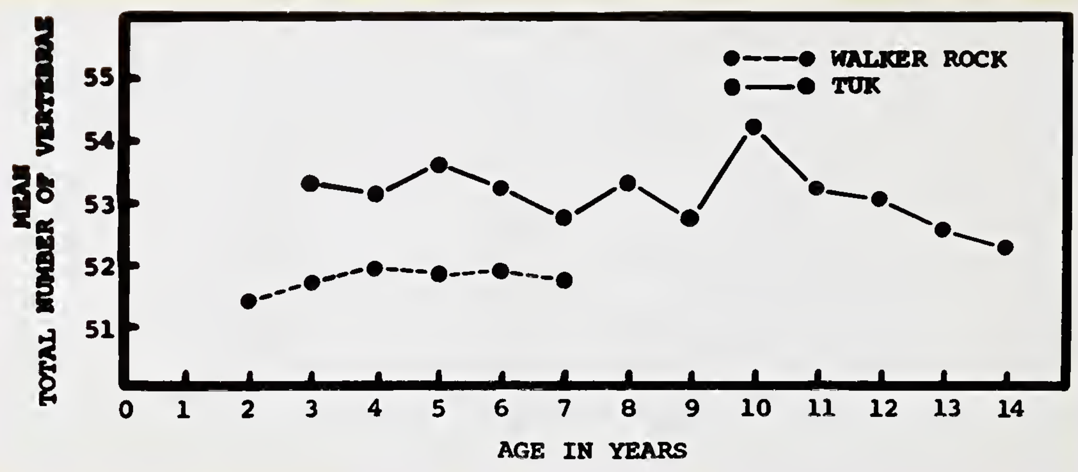

Fig. 21. Mean total number of vertebrae for various ages of herring from Walker Rock and Tuk.

at Tuk during the spawning and incubation period would result in herring with a slightly higher vertebral count then herring developing in the warmer waters of the Husky Lakes.

Figure 21 shows the mean numbers of vertebrae plotted against age for the herring of Walker Rock and Tuk. In the Tuk sample small numbers of aged fish in each year class (two to 11 for all ages except 54 for age four) make the data somewhat unreliable. No trend with age is seen, but the graph shows considerable variations in means from year to year. Walker Rock vertebral means show a slight upward trend from ages two to four followed by a levelling off. This trend may not be significant because the Walker Rock sample contained considerably fewer herring at ages two and three than ages four to six. Tester (1937a) found a small but significant increase in the mean vertebral count of a year class with age in British Columbia herring and suggested that the cause might be a differential mortality with respect to numbers of vertebrae. It is necessary to follow a year class, by successive yearly samples, to determine the presence of any change in the mean number of vertebrae with age.

The mean fork lengths for each total vertebral count in each age group were calculated for both Walker Rock and Tuk and the results showed that in both populations there is a trend for fish with more vertebrae to be slightly longer. These results corroborate Tester (1937a) who found that larger British Columbia

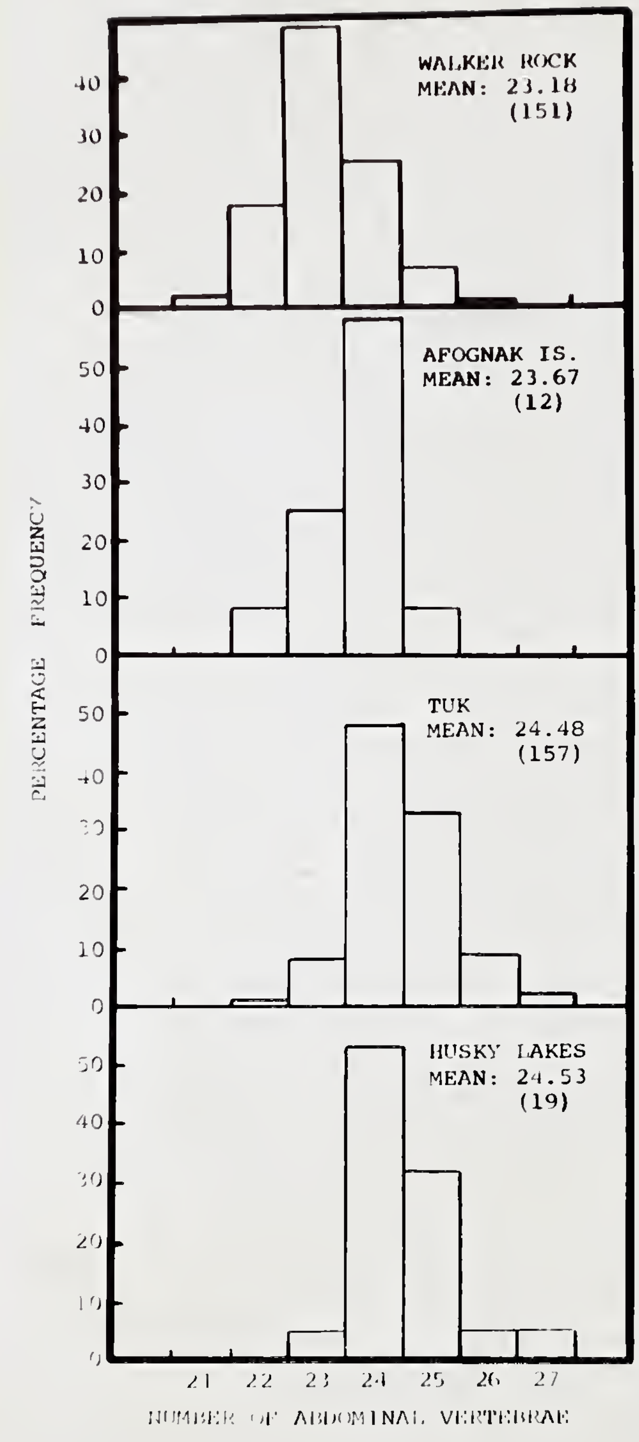

Fig. 22. Distributions of abdominal vertebrae for the four localities investigated.

herring, within a year class, were found to have higher vertebral counts. Tuk herring with larger numbers of vertebrae may have been spawned earlier in the season and may have developed in a relatively colder environment than fish spawned at a later date. The earlier spawned fish would also grow to a greater length than later spawned fish in their first summer because of the longer growing period before the onset of winter. The summer at Tuk lasts only about three months and spawnings two weeks apart could result in the later spawned individuals having one-sixth less time to feed and grow during the most favorable season, than fish spawned two weeks earlier.

Abdominal vertebrae

Table X gives the mean numbers of abdominal vertebrae for the four localities investigated and Figure 22 shows the percentage distributions of abdominal vertebrae.

Table X. Abdominal vertebral count means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean ± 3 S. D.
Walker Rock	151	23.18	0.072	0.88	20.54 to 25.82
Afognak Is.	12	23.67	0.225	0.78	21.33 to 26.01
Tuk	157	24.48	0.069	0.86	21.90 to 27.06
Husky Lakes	19	24.53	0.202	0.88	21.89 to 27.17

The abdominal vertebral count mean of Walker Rock differs significantly from that of Tuk with calculated t=13.13 much greater than P=0.01 (2.59), and Husky Lakes t=6.31, P at 0.01 (2.51). Walker Rock does not differ significantly from Afognak Island with t=2.01 less than P=0.01 (2.35). Afognak Island differs significantly from both Tuk (t=3.43, P at 0.01=2.61) and Husky Lakes (t=2.85, P at 0.01=2.76). Tuk and Husky Lakes do not differ significantly (t=0.24, P at 0.50=0.68). The mean numbers of abdominal vertebrae distinguish between Pacific and Arctic herring, but no significant difference is found between Tuk and Husky Lakes or between Walker Rock and Afognak Island. Comparisons of numbers of abdominal vertebrae show that Pacific herring are more similar to each other than to Arctic herring, and also that Arctic herring are more similar to each other than to Pacific herring. The Arctic samples have higher mean numbers of abdominal vertebrae than the Pacific samples and the data show an upward gradation with increasing latitude.

Caudal vertebrae

Table XI gives the mean numbers of caudal vertebrae for the four localities investigated and Figure 23 shows the percentage distributions of caudal vertebrae.

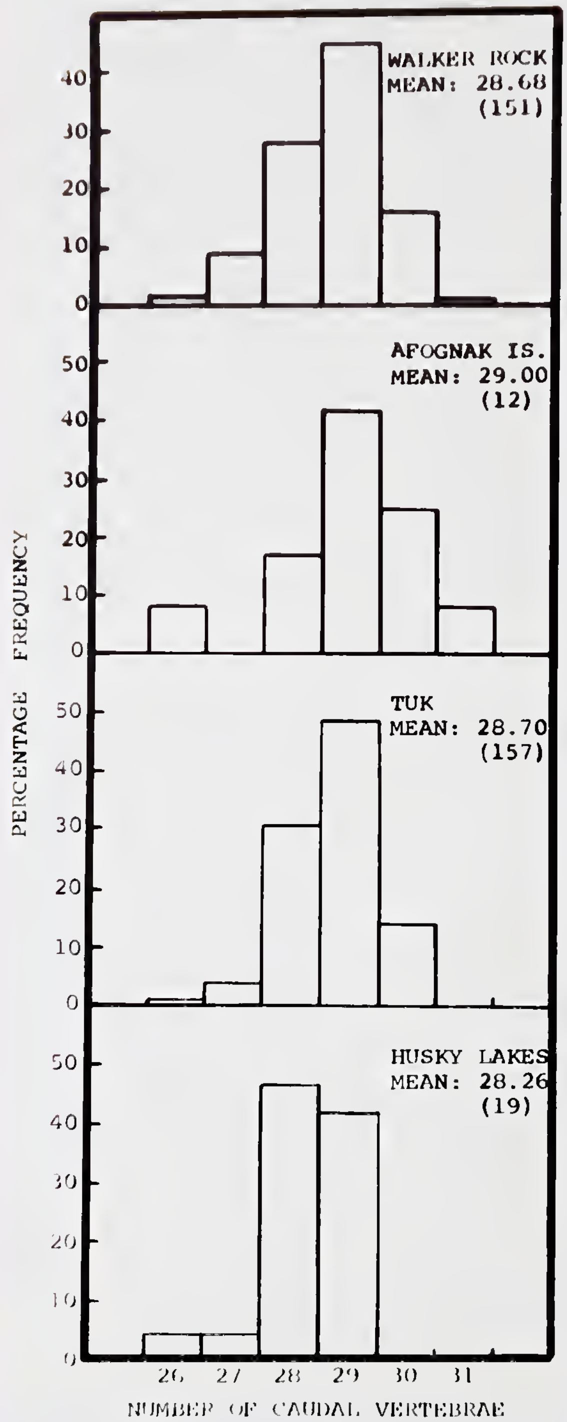

Fig. 23. Distributions of caudal vertebrae for the four localities investigated.

Table XI. Caudal vertebral count means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean ± 3 S. D.
Walker Rock	151	28.68	0.072	0.91	25.95 to 31.41
Afognak Is.	12	29.00	0.370	1.28	25.16 to 32.84
Tuk	157	28.70	0.072	0.90	26.00 to 31.40
Husky Lakes	19	28.26	0.181	0.79	25.89 to 30.63

The caudal vertebral count mean of Walker Rock does not differ significantly from either Tuk (t=0.19, P at 0.50=0.68), or Afognak Island (t=0.86, P at 0.10=1.66), or Husky Lakes with t=2.15 (P at 0.01=2.35). Afognak Island does not differ significantly from either Tuk (t=0.80, P at 0.10=1.66) or Husky Lakes (t=0.56, P at 0.50=0.68). Tuk and Husky Lakes do not differ significantly (t=2.32, P at 0.01=2.61). No significant differences exist among the four samples. The mean numbers of caudal vertebrae vary slightly among localities but do not follow a latitudinal cline. The caudal vertebrae of the herring, despite possessing means around five units greater than abdominal vertebrae means, show little variation among the samples. Consequently, the mean numbers of caudal vertebrae are of no value in distinguishing between herring from the four localities.

Table XII gives the mean numbers of abdominal and caudal vertebrae for each total vertebral count for the four localities

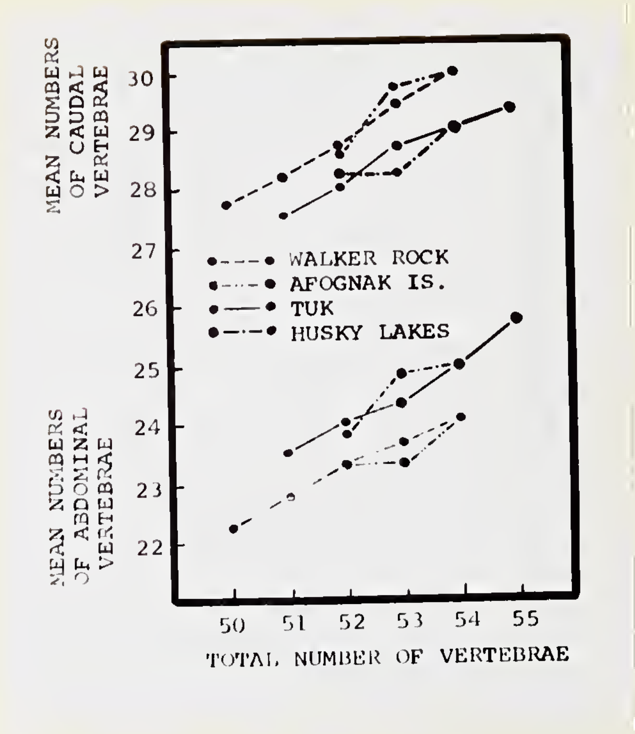

Fig. 24. Mean numbers of abdominal and caudal vertebrae for each total vertebral count for the four localities investigated.

investigated.

Table XII. Mean numbers of abdominal and caudal vertebrae for each total vertebral count for the four localities investigated.

Locality	Total vertebrae	Mean number of abdominal vertebrae	Mean number of caudal vertebrae	Number of fish
Walker Rock	50	22.25	27.75	4
	51	22.76	28.24	38
	52	23.30	28.70	87
	53	23.62	29.38	21
	54	24.00	30.00	1
Afognak Is.	51	25.00	26.00	1
	52	23.40	28.60	5
	53	23.33	29.67	3
	54	24.00	30.00	3
Tuk	51	23.50	27.50	2
	52	24.00	28.00	27
	53	24.28	28.72	81
	54	24.97	29.03	29
	55	25.70	29.30	10
Husky Lakes	52	23.80	28.20	5
	53	24.77	28.23	13
	54	25.00	29.00	1

Figure 24 shows that an increase in the total number of vertebrae is caused by increases in numbers of both abdominal and caudal vertebrae. Over the total vertebral range, the Walker Rock caudal vertebrae showed a greater increase than the abdominal vertebrae, whereas Tuk abdominal vertebrae showed a greater increase than the caudal vertebrae. Approximate slopes of the lines representing increases in mean numbers of abdominal and caudal vertebrae

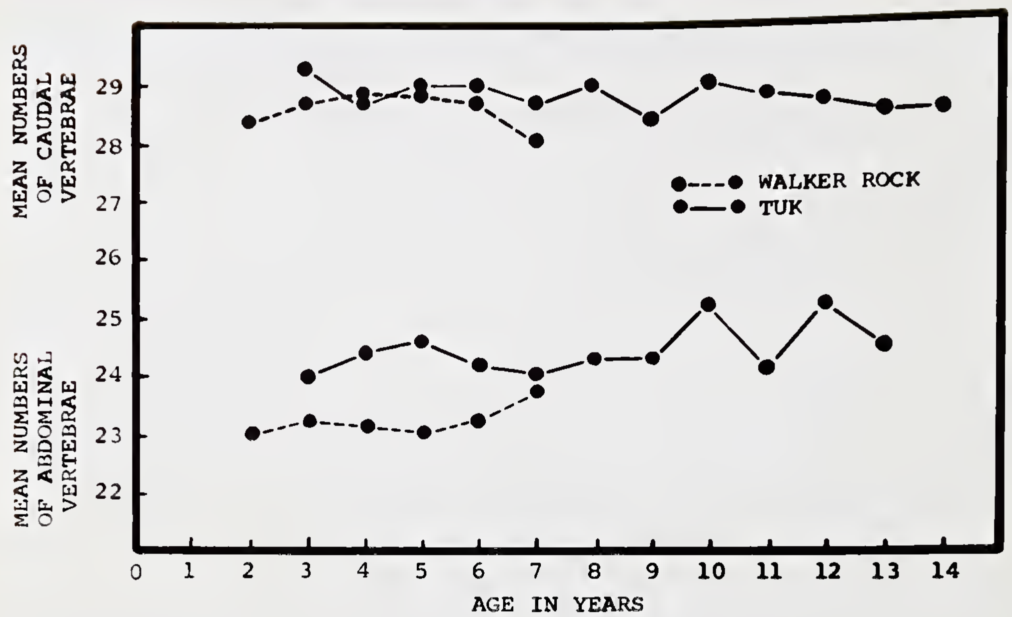

Fig. 25. Mean numbers of abdominal and caudal vertebrae for herring of various ages from Walker Rock and Tuk.

were calculated from data of the total vertebrae classes which contained 21 or more specimens. The slopes are for Walker Rock: abdominal vertebrae--0.40, caudal vertebrae--0.60; and for Tuk: abdominal vertebrae--0.50, caudal vertebrae--0.50. These slopes show that, with increase in the total number of vertebrae, in the Walker Rock sample the mean number of caudal vertebrae shows a proportionately greater increase than the mean number of caudal vertebrae, whereas in the Tuk sample the mean numbers of abdominal and caudal vertebrae show approximately the same increase.

Walker Rock herring have a greater gap between the mean numbers of caudal and abdominal vertebrae for any given total number of vertebrae than have Tuk herring. Figure 24 shows that the slopes and ranges of Afognak Island and Husky Lakes closely resemble those of Walker Rock and Tuk respectively.

Figure 25 shows that abdominal and caudal vertebrae means for each age group of herring from Walker Rock and Tuk. In both samples there is a tendency for the mean numbers of caudal vertebrae to decrease and the mean numbers of abdominal vertebrae to increase with age, but no conclusions can be made on the trends in numbers with age because of the few fish in most of the age groups.

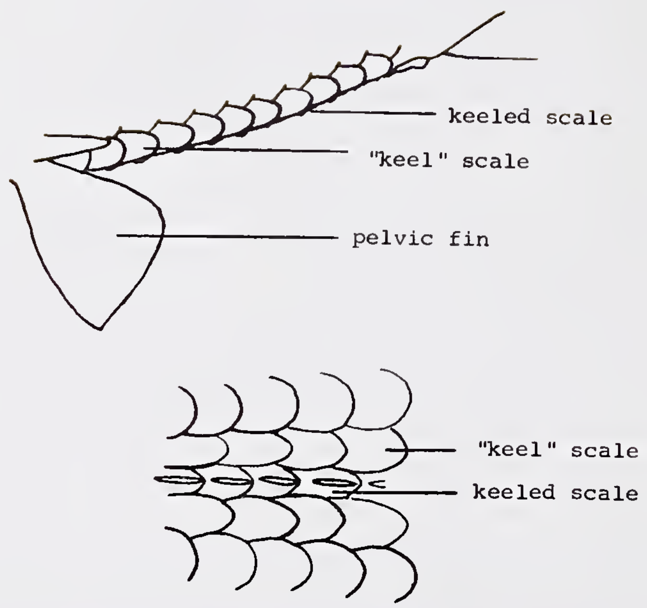

Fig. 26. Diagram showing "keel" scales,

lateral view (top) and ventral view (bottom).

2. "Keel" scales

"Keel" scales, as designated by the author, are the number of scales whose ventral sides lie along side the keel of the abdomen from the base of the pelvic fins to the anus (Fig. 26).

Table XIII. "Keel" scale count means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean ± 3 S. D.
Walker Rock	196	10.26	0.048	0.67	8.25 to 12.27
Afognak Is.	12	11.58	0.220	0.76	9.30 to 13.86
Tuk	159	10.94	0.048	0.61	9.11 to 12.77
Husky Lakes	22	11.32	0.117	0.55	9.67 to 12.97

Significant differences in "keel" scale count means were present between Walker Rock and Tuk (t=10.00, P at 0.01=2.59), Walker Rock and Afognak Island (t=5.87, P at 0.01=2.60), Walker Rock and Husky Lakes (t=8.41, P at 0.01=2.60), Tuk and Afognak Island (t=2.84, P at 0.01=2.61), and Tuk and Husky Lakes (t=3.02, P at 0.01=2.60). No significant difference was found between Afognak Island and Husky Lakes (t=0.96, P at 0.10=1.68). The modes for Walker Rock and Tuk were 10 and 11 respectively and

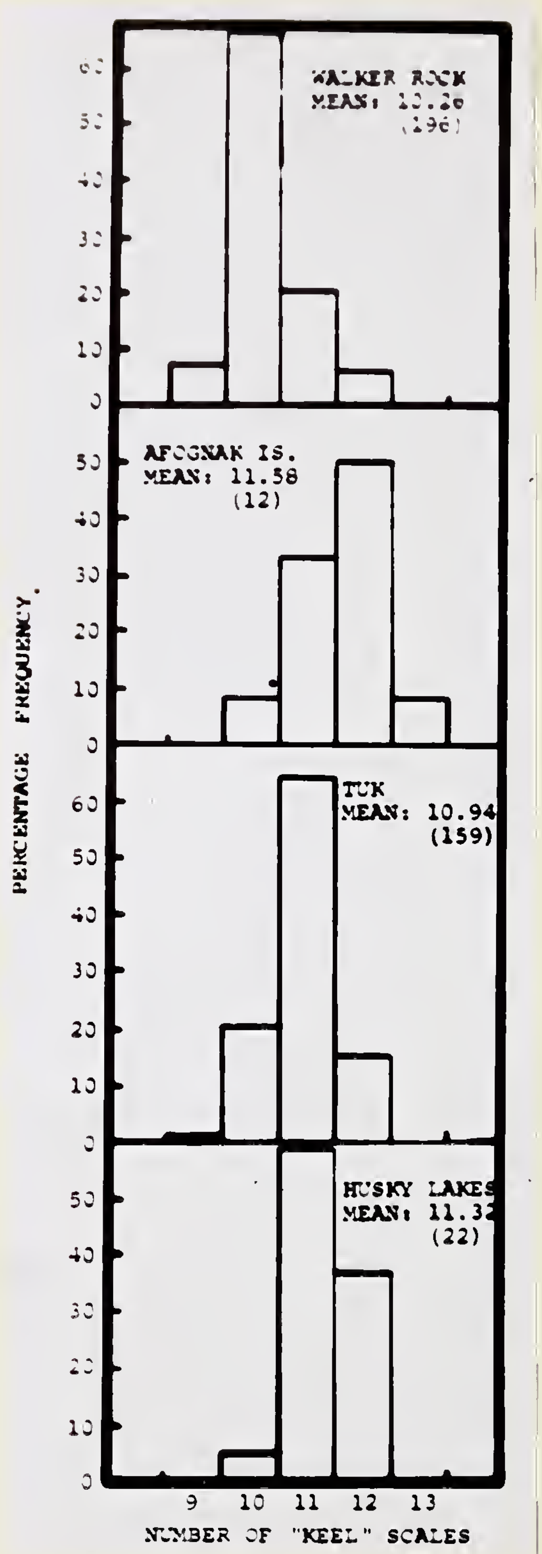

Fig. 27. "Keel" scale count distributions for the four localities investigated.

showed clearly that the character tends to increase with latitude (Fig. 27). Variation between localities at the same latitude is present, however, as is shown by Tuk and Husky Lakes with a mean difference of 0.38 "keel" scales.

Tester (1937a) found that the keeled scale counts of northern localities averaged less than those of southern localities in British Columbia. According to Tester (1937a), Hessle in 1925 found a similar gradation among autumn spawned herring of the Swedish Baltic coast and suggested a correlation between fewer numbers of keeled scales and decreasing salinity. Hessle also suggested temperature as a possible affecting factor. The adjacent proximity of the "keel" scales to the keeled scales suggests that the same environmental influences would similarly affect the numbers of each. Temperature and salinity data from the various localities during incubation and after hatching to the time of scale formation might shed light on the causes of variation in numbers of "keel" scales. The distance between the base of the pelvic fins and the anus reflects the growth rate of a fish and at the time of scale formation probably this distance affects the number of "keel" scales produced. Temperature, salinity, amount of food present during early life, and other environmental factors might affect the number of "keel" scales indirectly through influencing the growth rate.

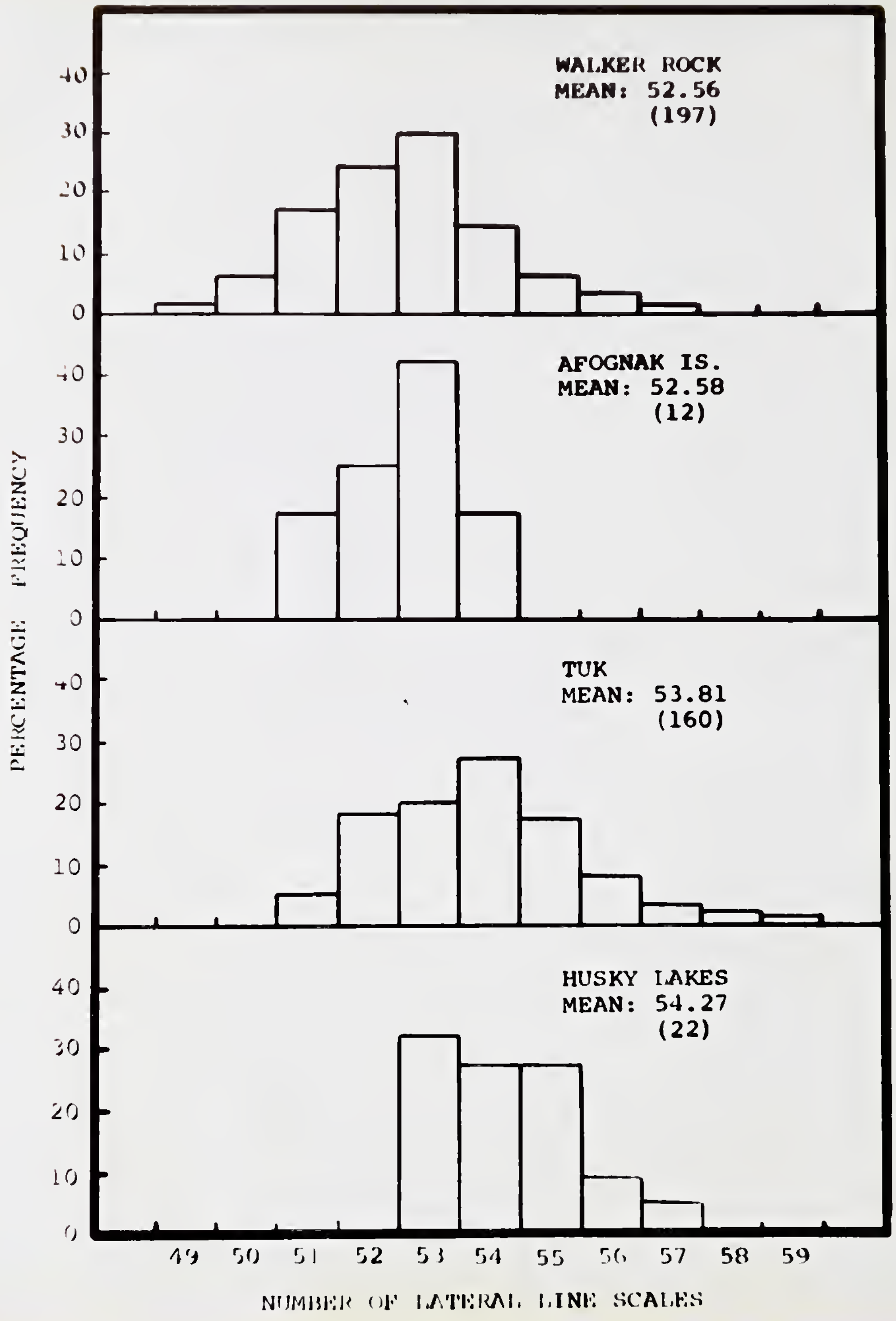

Fig. 28. Lateral line scale count distributions for the four localities investigated.

3. Lateral line scales

The lateral line scale count used in this study is the number of scales along the mid-lateral scale row from the opercular opening to the base of the caudal fin.

Table XIV. Lateral line scale means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean ± 3 S. D.
Walker Rock	197	52.56	0.102	1.44	48.24 to 56.88
Afognak Is.	12	52.58	0.289	1.00	49.58 to 55.58
Tuk	160	53.81	0.126	1.60	49.01 to 58.61
Husky Lakes	22	54.27	0.275	1.29	50.40 to 58.14

Significant differences in lateral line scale count means were present between Walker Rock and Tuk (t=7.66, P at 0.01=2.59), Walker Rock and Husky Lakes (t=5.83, P at 0.01=2.60), Afognak Island and Tuk (t=4.03, P at 0.01=2.26), and Afognak Island and Husky Lakes (t=4.25, P at 0.01=2.75). No significant differences were found between Walker Rock and Afognak Island (t=0.02, P at 0.50=0.68), and Tuk and Husky Lakes (t=0.48, P at 0.50=0.68). Figure 28 shows that the two Pacific samples closely resemble each other, both possessing a mode of 53. The two Arctic samples also closely resemble each other, but possess higher mean numbers of lateral line scales. The number of lateral line scales shows

considerable variation between northern Arctic and more southern Pacific herring and is useful to distinguish between herring from the two areas.

Mottley (1934) and Wilder (1952) showed that the number of scales could be influenced by different temperatures. The number of lateral line scales varies with the length of an individual of a species at the time of scale formation (Brown, 1957). The number of lateral line scales is therefore affected by the growth of the fish, which is in turn under genetic and environmental influence.

Since the number of vertebrae in the herring is determined before hatching, and since longer fish tend to have more vertebrae, correlation coefficients were calculated for both Walker Rock and Tuk to see with what consistency the two characters, vertebrae and lateral line scales, keep in step. Positive correlation coefficients of +0.87 for Walker Rock and +0.84 for Tuk were obtained and indicated a significant relationship between the numbers of vertebrae and lateral line scales. This means that herring with a higher number of vertebrae tend to have more lateral line scales than herring with a lower number of vertebrae.

4. Dorsal scales

Dorsal scales are the scales from the origin of the dorsal fin, counting postero-ventrally to but not including the mid-lateral line.

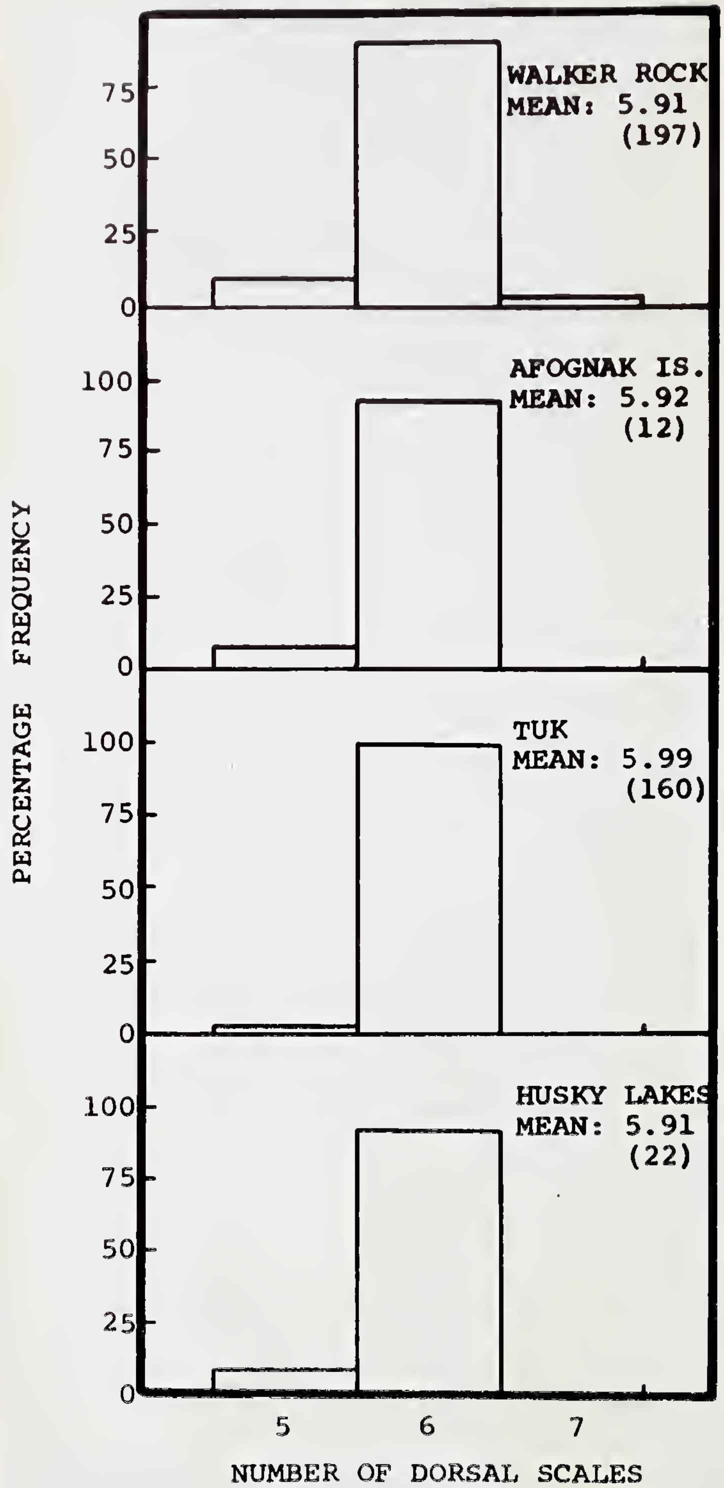

Fig. 29. Dorsal scale count distributions for the four localities investigated.

Table XV. Dorsal scale means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean $\pm$ 3 S. D.
Walker Rock	197	5.91	0.013	0.18	5.37 to 6.45
Afognak Is.	12	5.92	0.081	0.28	5.08 to 6.76
Tuk	160	5.99	0.006	0.08	5.75 to 6.23
Husky Lakes	22	5.91	0.062	0.29	5.04 to 6.78

The only significant difference found was between Walker Rock and Tuk (t=5.80, P at 0.01=2.59). The differences between Walker Rock and Afognak Island, Afognak Island and Tuk, Afognak Island and Husky Lakes, and Tuk and Husky Lakes were not significant with the calculated values of t falling between P at 0.50 and P at 0.10. There was also no difference between the means of Walker Rock and Husky Lakes. All four samples had modes of six which contained from 90 to 99 percent of the individuals (Fig. 29). Only one herring of 160 from Tuk deviated from the mode. It had five dorsal scales. Walker Rock herring showed more variation in the numbers of dorsal scales than the Tuk herring. Of 197 Walker Rock herring, 19 had five, 177 had six, and only one had seven dorsal scales. No conclusions can be drawn from the Afognak Island and Husky Lakes data because of the small variation within the character and because of the small numbers in the samples.

The dorsal scale count character, because of its lack of

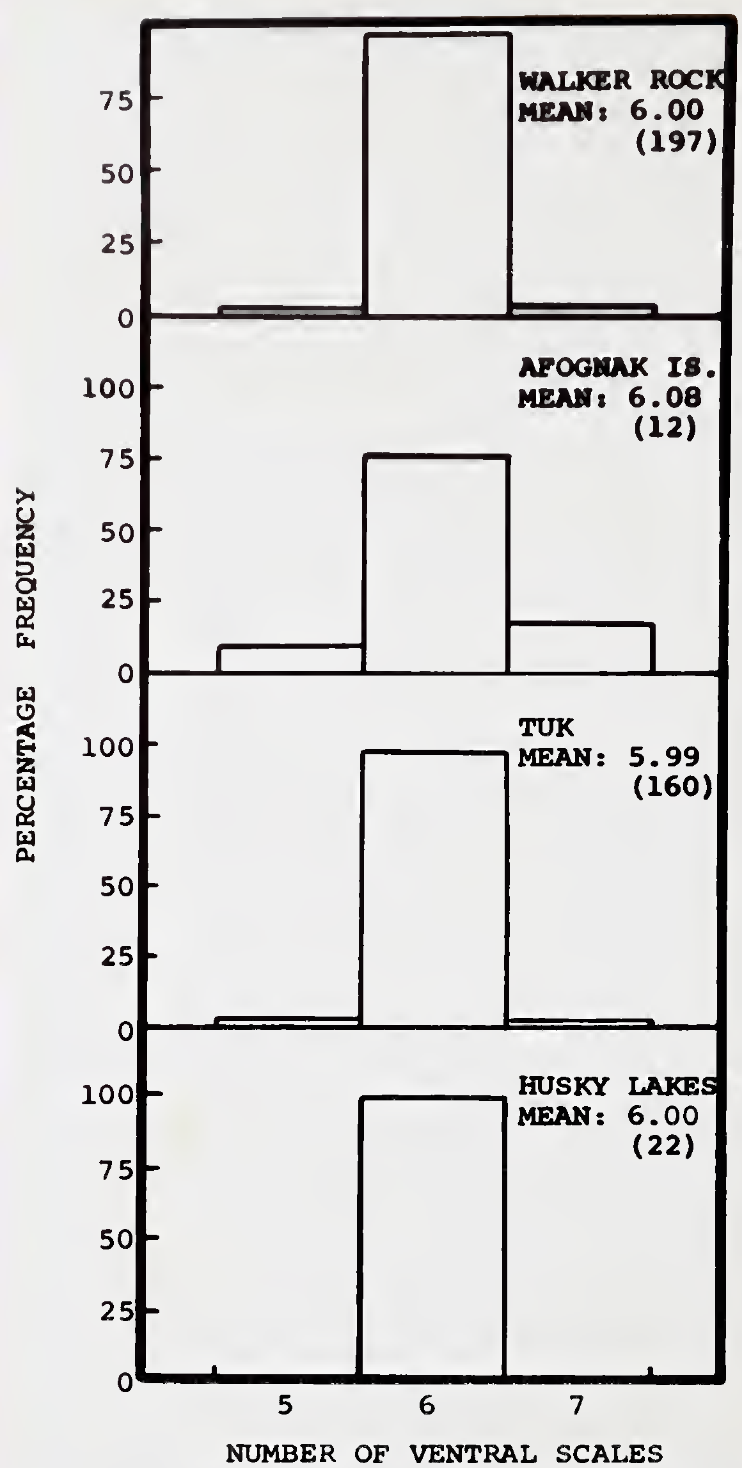

Fig. 30. Ventral scale count distributions for the four localities investigated.

variability, can be omitted as a diagnostic character among herring from the different localities observed in this study.

5. Ventral scales

Ventral scales are the scales from the origin of the anal fin counting antero-dorsally to but not including the mid-lateral line.

Table XVI. Ventral scale means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean $\pm$ 3 S. D.
Walker Rock	197	6.00	0.001	0.02	5.94 to 6.06
Afognak Is.	12	6.08	0.144	0.50	4.58 to 7.58
Tuk	160	5.99	0.040	0.50	4.49 to 7.49
Husky Lakes	22	6.00	0.000	0.00	6.00 $\pm$ 0.00

The ventral scale count means of the various localities were compared and no significant differences were found. In all comparisons the calculated t was smaller than P at 0.50 except for Walker Rock and Husky Lakes which had identical means. The modes of all four localities were six and contained 75 to 100 percent of the individuals (Fig. 30). In the Walker Rock sample, three herring had five ventral scales and four herring had seven, whereas in the Tuk sample, three herring had five ventral scales and one herring had seven. As with dorsal scales, little inference can be made

from the Afognak Island and Husky Lakes samples because of the small variation in the character and because of the few numbers in the samples.

The ventral scale count character was of no use in distinguishing between the samples from the various localities used in this study.

6. Gill rakers

The first left gill arch was removed from each fish and the gill rakers counted. Rudimentary rakers were included in the counts. A certain amount of error may be present because some rakers may have been accidentally cut off during the removal of the gill arches.

Table XVII. Gill raker means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. E.	Mean ± 3 S. D.
Walker Rock	195	64.14	0.147	2.05	57.99 to 70.29
Afognak Is.	12	65.75	0.488	1.69	60.68 to 70.82
Tuk	161	66.48	0.191	2.43	59.19 to 73.77
Husky Lakes	22	66.68	0.469	2.20	60.08 to 73.28

T-tests applied to the means of both males and females from

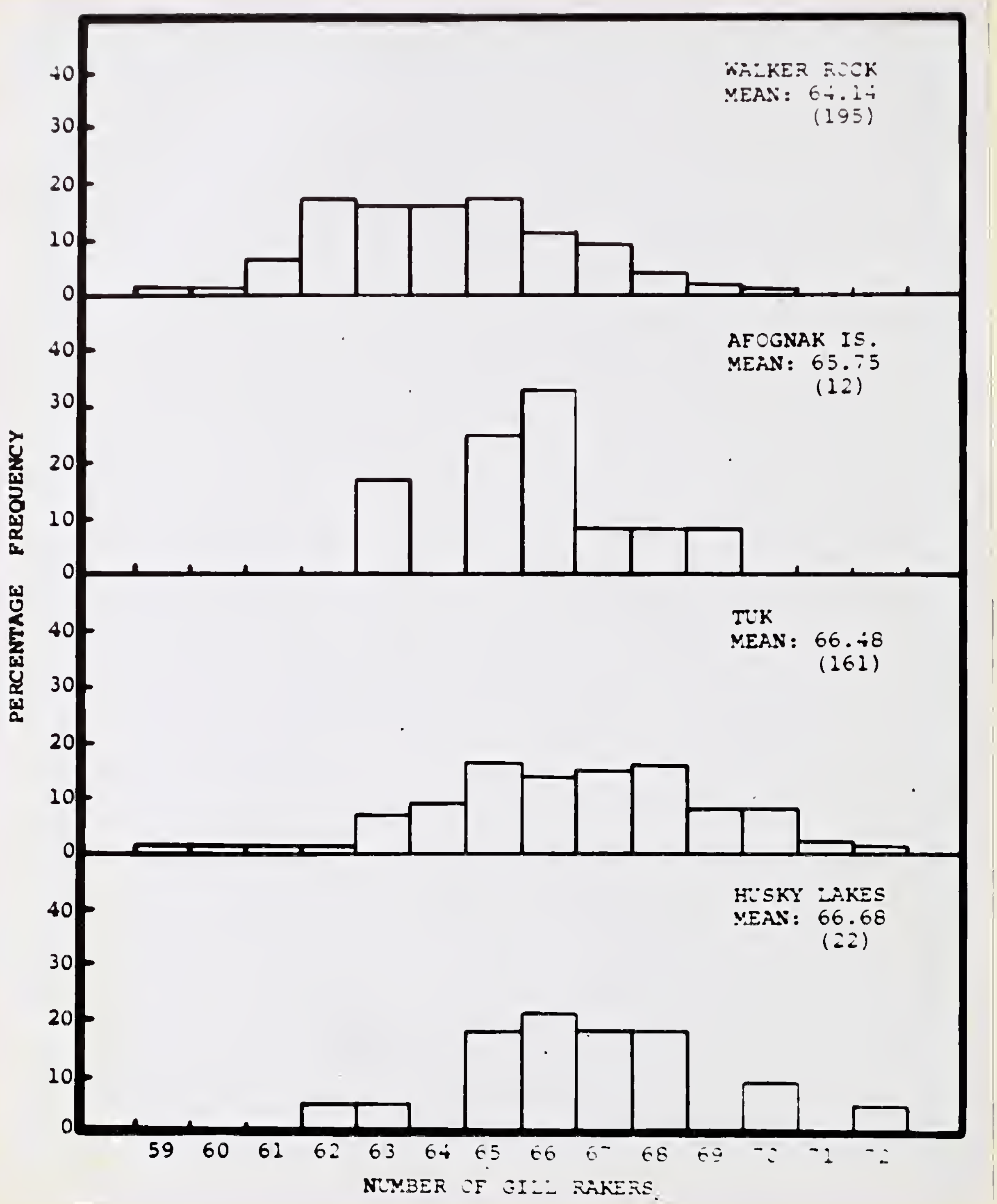

Fig. 31. Gill raker count distributions for the four localities investigated.

Walker Rock and Tuk showed that no significant differences exist between sexes. Males and females are therefore not segregated for the gill raker comparisons.

Significant differences are present between Walker Rock and Tuk ($t=9.71$, P at $0.01=2.59$), Walker Rock and Afognak Island ($t=3.15$, P at $0.01=2.60$), and Walker Rock and Husky Lakes ($t=5.17$, P at $0.01=2.60$). No significant differences were found between Afognak Island and Tuk ($t=0.001$, P at $0.50=0.68$), Afognak Island and Husky Lakes ($t=1.37$, P at $0.50=0.68$ and P at $0.10=1.70$), and Tuk and Husky Lakes ($t=0.04$, P at $0.50=0.68$).

Figure 31 shows the general increase in numbers of gill rakers from south to north.

Figure 32 shows the mean gill raker counts for each one centimeter fork length group of herring from Walker Rock and Tuk. The mean numbers of gill rakers increase with length, hence age, of the herring. Both populations show distinct curves and each has a mean increase of approximately two gill rakers over the fork length range represented. The Walker Rock increase occurs over a 50 millimeter fork length range, whereas the Tuk increase occurs over a much larger fork length range of 150 millimeters. Although gill rakers differ significantly between the widely separated herring of Walker Rock and Tuk, the gill raker means cannot be used to distinguish between Pacific and Arctic herring. Gill rakers show a latitudinal cline, increasing in numbers from south to north. The Afognak Island sample, from an intermediate area, although

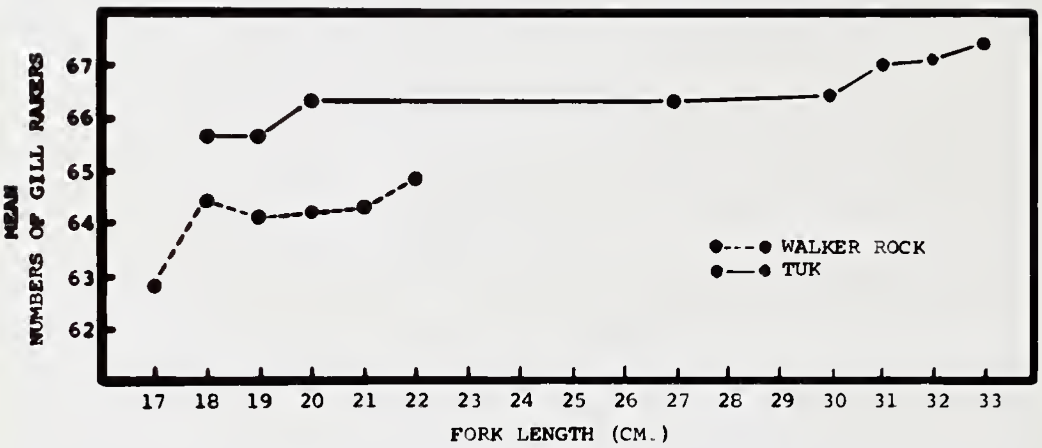

Fig. 32. Mean gill raker counts for each one centimeter fork length group of herring from Walker Rock and Tuk.

Pacific, does not show significant differences from the Arctic samples.

Correlation coefficients were calculated for the total number of vertebrae and gill rakers from both Walker Rock and Tuk to see what relationship, if any, there was between the two characters. No correlation was found to exist between the numbers of vertebrae and gill rakers for Walker Rock (r=0.01) or Tuk (r=0.01).

7. Dorsal fin rays

Dorsal fin rays included the one or two small fin rays anterior to the first long ray. The last two rays that are separated at the base of the fin were counted as one.

Table XVIII. Dorsal fin ray means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean ± 3 S. D.
Walker Rock	196	17.99	0.054	0.76	15.71 to 20.27
Afognak Is.	12	17.75	0.208	0.72	15.59 to 19.91
Tuk	160	17.98	0.065	0.82	15.52 to 20.44
Husky Lakes	22	17.86	0.162	0.76	15.58 to 20.14

T-tests showed no significant differences present between the various localities: Walker Rock and Afognak Island (t=1.12, P at

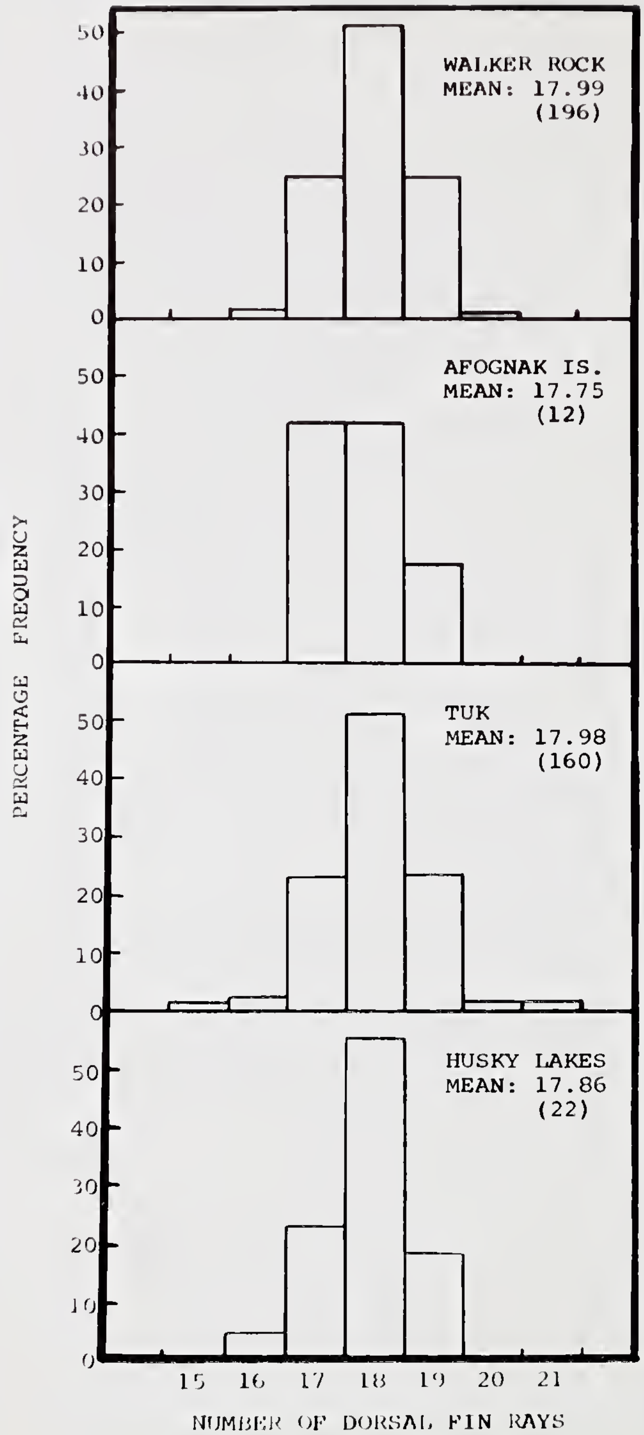

Fig. 33. Dorsal fin ray count distributions for the four localities investigated.

0.10=1.65), Walker Rock and Tuk (t=0.12, P at 0.50=0.68), Walker Rock and Husky Lakes (t=0.76, P at 0.10=1.65), Afognak Island and Tuk (t=1.06, P at 0.10=1.66), Afognak Island and Husky Lakes (t=0.42, P at 0.50=0.68), and Tuk and Husky Lakes (t=0.68, P at 0.50=0.68). The number of dorsal fin rays showed no consistent pattern of variation with geographical location. Populations of herring in Alaska are similar in this respect (Rounsefell, 1930). The modes of Walker Rock, Tuk, and Husky Lakes are all 18 (Fig. 33). Afognak Island has equal numbers of herring at both 17 and 18. The dorsal fin ray means of various populations of Alaskan herring (Rounsefell, 1930) were approximately one fin ray larger than the means of the herring in the present study. This is caused by a difference in methods of counting fin rays; Rounsefell evidently counted the last two ray elements as separate units.

Lindsey (1954) found that the number of spines and rays in the dorsal fin of the paradise fish (Macropodus opercularis) was relatively insensitive to different sustained temperatures during development. This may shed some light on the reasons for the small and insignificant differences between herring from the various localities in the present study. It is possible that the number of dorsal fin rays in herring is rigidly controlled by genetic factors, the character showing limited phenotypic plasticity.

The means of the dorsal fin ray counts were found to be of no value in separating Pacific and Arctic herring, or distinguishing between samples from within each of these areas.

8. Anal fin rays

Anal fin rays included in the count the one or two small rays at the anterior of the fin. The last two fin rays that are separated at the base of the fin were counted as one.

Table XIX. Anal fin ray means for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean $\pm$ 3 S. D.
Walker Rock	196	15.96	0.057	0.80	13.56 to 18.36
Afognak Is.	12	15.67	0.214	0.74	13.45 to 17.89
Tuk	160	15.81	0.090	1.14	12.09 to 19.53
Husky Lakes	21	16.81	0.129	0.59	15.04 to 18.58

Significant differences were found between Walker Rock and Husky Lakes (t=6.03, P at 0.01=3.34), Afognak Island and Husky Lakes (t=4.56, P at 0.01=3.65), and Tuk and Husky Lakes (t=6.37, P at 0.01=2.60). No significant differences were found between Walker Rock and Tuk (t=1.40, P at 0.10=1.65), Walker Rock and Afognak Island (t=1.31, P at 0.10=1.65), and Afognak Island and Tuk (t=0.60, P at 0.50=0.68). Rounsefell (1930) found that the anal fin ray means of Alaskan herring varied within and between localities but found no general change with distance as was shown by total vertebral counts. Rounsefell's (1930) means were approximately one ray higher because his counts evidently counted the last two

rays as separate units.

Lindsey (1953) found a positive correlation between water temperatures, in the vicinities of developing fry, and mean anal fin ray counts of the redside shiner (Richardsonius balteatus) in British Columbia. More northern individuals possessed higher mean counts than southern populations. Lindsey (1954) found that in the paradise fish (Macropodus opercularis), the number of anal fin rays was subject to environmental temperature influence up to 22 days after fertilization. Therefore the relationship between temperature and anal fin ray numbers has been established in some species of fish. The mean numbers of anal fin rays compared in the present study show no gradual change with latitude. Wide variations in means occur between both widely separated and closely located localities. Husky Lakes, for example, differs from Tuk by one fin ray, but from very distant Walker Rock by only 0.85 rays. The high anal fin ray mean of Husky Lakes, responsible for the significant differences between this area and the herring from Walker Rock and Afognak Island, is not evidence that the character can be used to distinguish between Pacific and Arctic herring, or that there is an increase in the mean with an increase in latitude. The high mean for the Husky Lakes is an indication of a population quite distinct, probably subject to different environmental conditions, from the other three localities. Husky Lakes differs most from Tuk. This indicates little or no intermingling between the two populations from which samples were taken, even though they

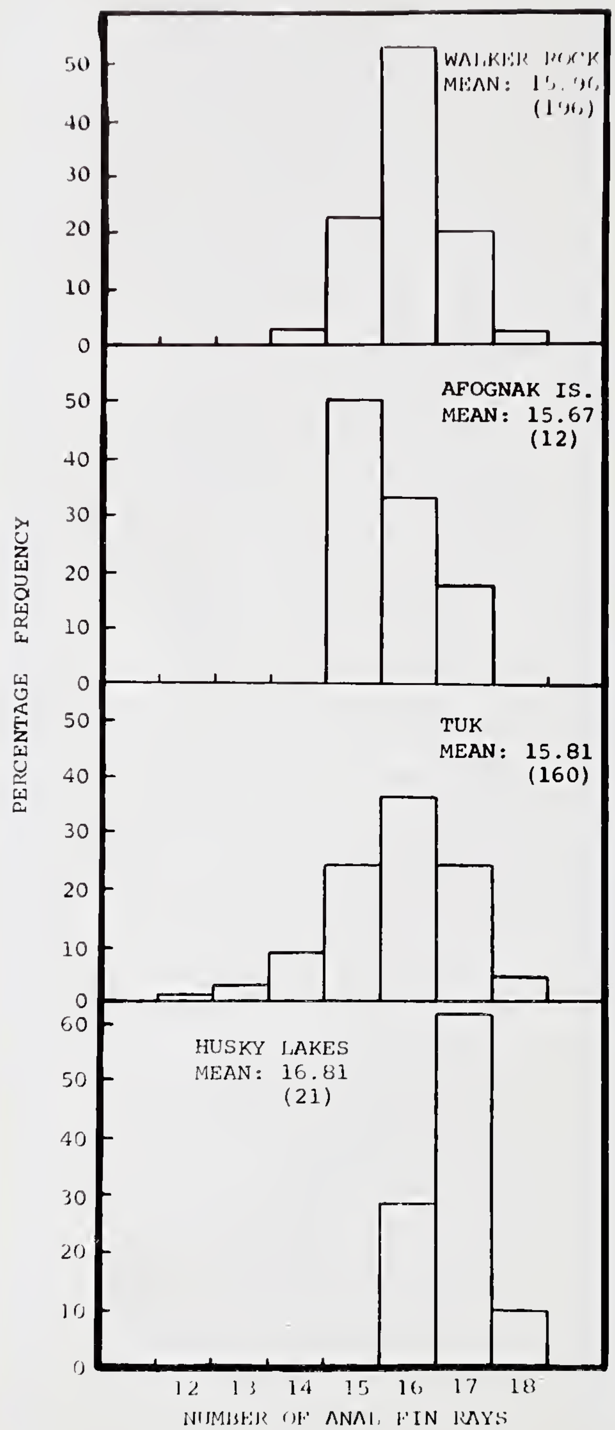

Fig. 34. Anal fin ray count distributions for the four localities investigated.

are the most closely located geographically of the four localities investigated.

The sample from Tuk shows more variability in anal fin ray numbers than does the sample from Walker Rock (Fig. 34). Perhaps some environmental factor, such as temperature, affecting the number of anal fin rays in herring has a greater range of variation during the time of development of the Tuk herring. Herring spawned and incubated at different times might possibly reflect variation in the influencing factor by differences in numbers of anal fin rays.

9. Pectoral fin rays

The total pectoral fin ray count includes the number of rays in both pectoral fins.

Table XX. Means of total pectoral fin rays for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean $\pm$ 3 S. D.
Walker Rock	196	35.28	0.096	1.34	31.26 to 39.30
Afognak Is.	12	33.67	0.477	1.65	28.72 to 38.62
Tuk	158	33.59	0.102	1.28	29.75 to 37.43
Husky Lakes	22	34.50	0.260	1.22	30.90 to 38.10

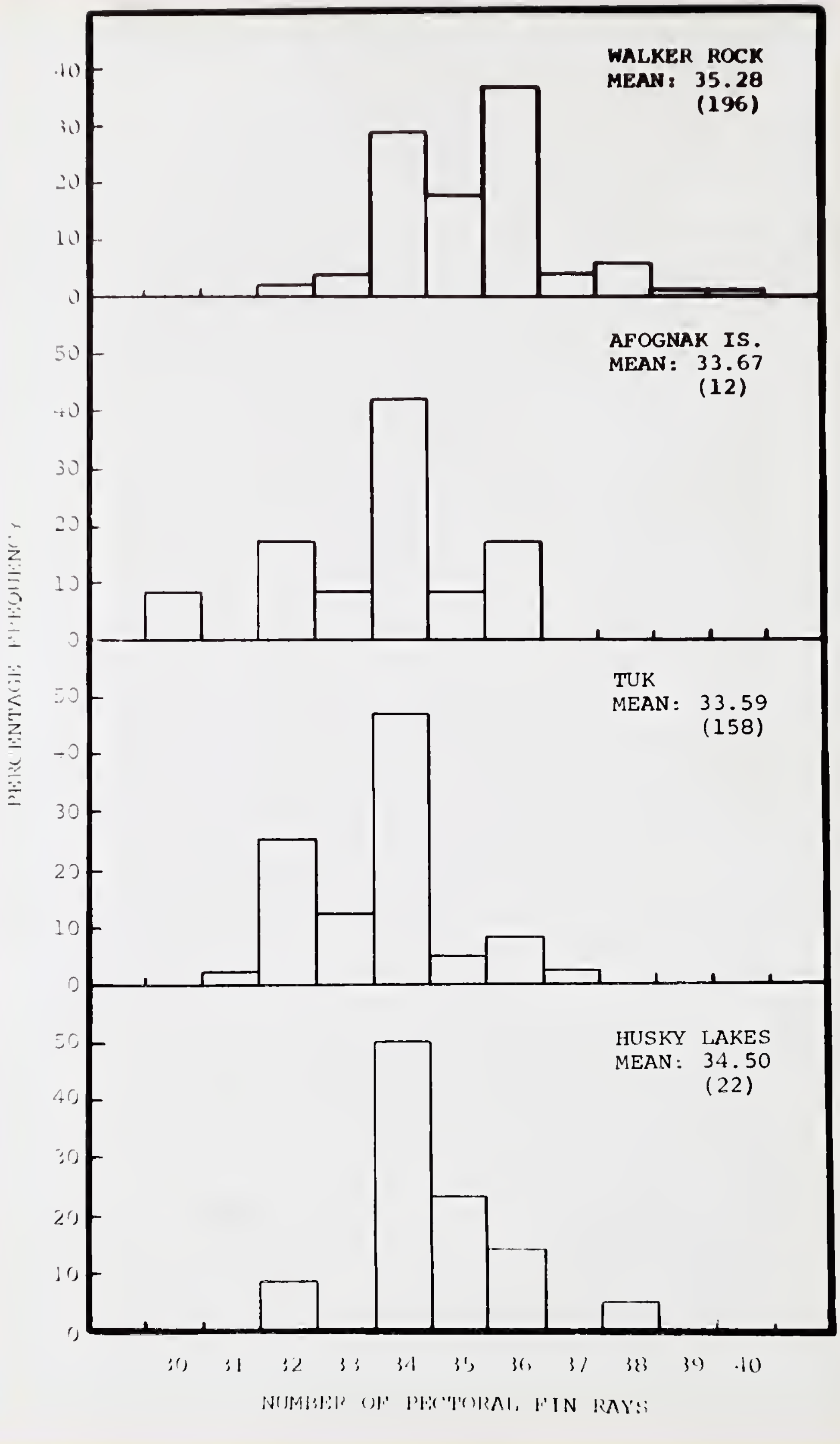

Fig. 35. Distributions of numbers of pectoral fin rays for the four localities investigated.

According to Tester (1937a), Schnakenbeck in 1927 considered the pectoral fin ray count as a good racial character for distinguishing among Atlantic herring. Tester (1937a) used the pectoral fin ray count in studies on the herring of British Columbia and found no significant differences between adjacent or distant localities.

Significant differences were found between Walker Rock and Tuk (t=12.07, P at 0.01=2.59), Walker Rock and Afognak Island (t=3.31, P at 0.01=2.60), Walker Rock and Husky Lakes (t=2.82, P at 0.01=2.60), and Tuk and Husky Lakes (t=3.25, P at 0.01=2.59). No significant differences were found between Afognak Island and Tuk (t=0.16, P at 0.50=0.68), and Afognak Island and Husky Lakes (t=1.53, P at 0.10=1.66). The total pectoral fin ray counts varied widely from 32 to 40 for Walker Rock, and from 31 to 37 for Tuk (Fig. 35). Most Walker Rock herring had 34 to 36 fin rays, whereas most herring from Tuk had 32 to 34 fin rays. The low odd number counts of 35 and 37 for Walker Rock and 33 and 35 for both Afognak Island and Tuk reflect a definite correlation between the number of rays in each pectoral fin. The data suggest a decrease in the mean total pectoral fin ray count with latitude.

10. Pelvic fin rays

The total pelvic fin ray count includes the number of rays in both pelvic fins.

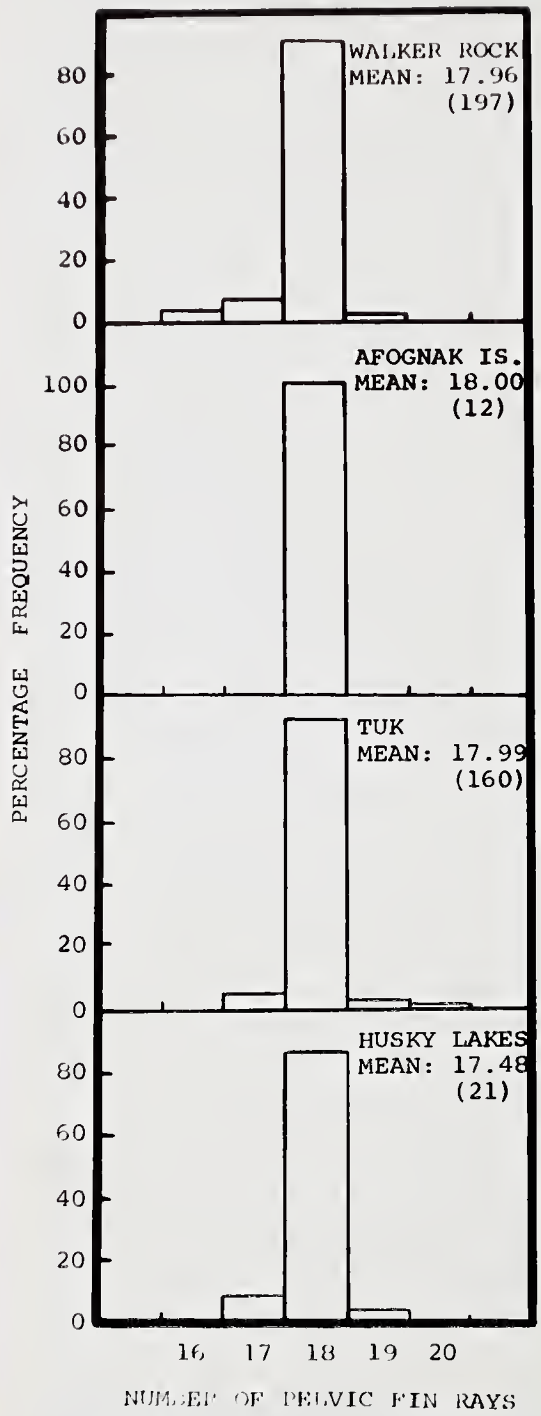

Fig. 36. Distributions of numbers of pelvic fin rays for the four localities investigated.

Table XXI. Means of total pelvic fin rays for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean ± 3 S. D.
Walker Rock	197	17.96	0.031	0.44	16.64 to 19.28
Afognak Is.	12	18.00	0.000	0.00	18.00 to 0.00
Tuk	160	17.99	0.024	0.31	17.06 to 18.92
Husky Lakes	21	17.48	0.131	0.60	15.68 to 19.28

Significant differences were present between Husky Lakes and Walker Rock ($t=3.58$, P at $0.01=2.60$), Husky Lakes and Tuk ($t=3.83$, P at $0.01=2.60$), and Husky Lakes and Afognak Island ($t=3.97$, P at $0.01=2.75$). No significant differences were found between Walker Rock and Afognak Island ($t=1.59$, P at $0.10=1.65$), Walker Rock and Tuk ($t=0.75$, P at $0.10=1.65$), and Afognak Island and Tuk ($t=0.001$, P at $0.50=0.68$). The pelvic fin ray count shows almost no variation among the four localities, each with a mode of 18 (Fig. 36). The Husky Lakes sample has the lowest mean of 17.48. A much larger sample is required than that from Husky Lakes to determine the true picture of this character count which first~~ly~~, has only a low mean, and second~~ly~~, varies only slightly about that mean. The Afognak Island sample does not truly represent the population from which it was taken because it is highly unlikely that no variation in the total number of pelvic fin rays is present.

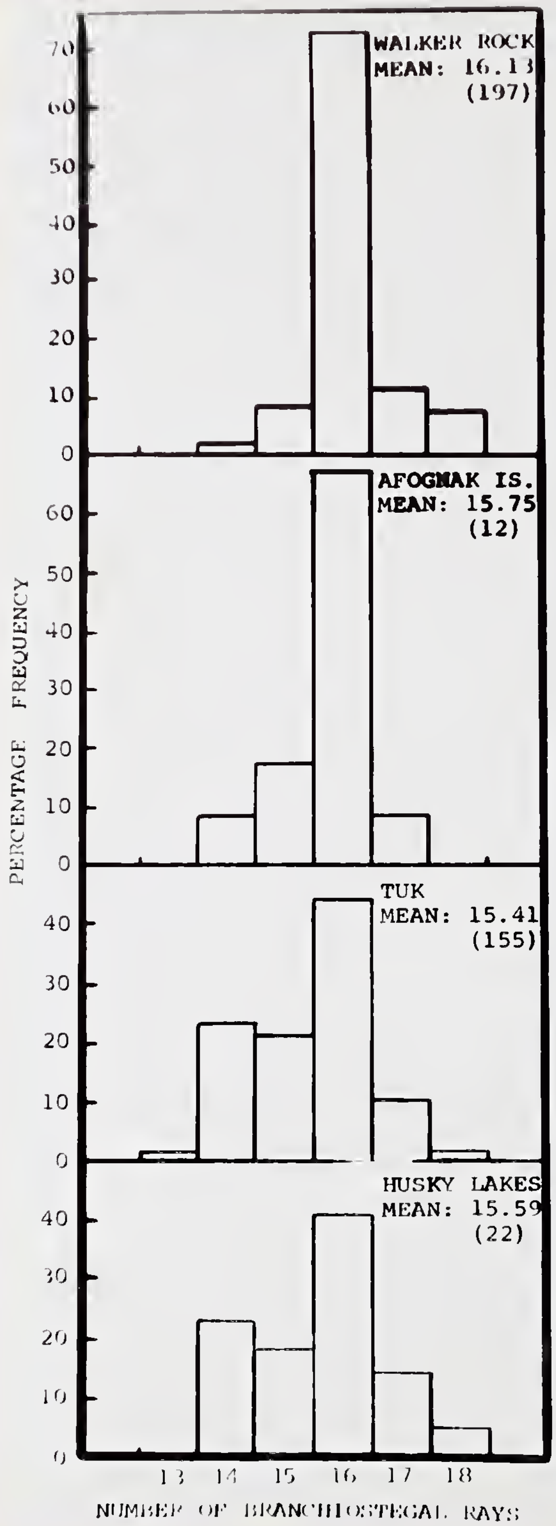

Fig. 37. Distributions of numbers of branchiostegal rays for the four localities investigated.

Again a larger sample would overcome this error.

The total pelvic fin ray count is of no use as a diagnostic character to distinguish between Pacific and Arctic herring.

11. Branchiostegal rays

The number of branchiostegal rays on each side was ~~were~~ counted and the two sides summed.

Table XXII. Mean numbers of branchiostegal rays for the four localities investigated.

Locality	Number of fish	Mean	S. E.	S. D.	Mean ± 3 S. D.
Walker Rock	197	16.13	0.051	0.71	14.00 to 18.26
Afognak Is.	12	15.75	0.208	0.72	13.59 to 17.91
Tuk	155	15.41	0.081	1.01	12.38 to 18.44
Husky Lakes	22	15.59	0.239	1.12	12.23 to 18.95

A significant difference was found between Walker Rock and Tuk (t=7.58, P at 0.01=2.59). No significant differences were found between Walker Rock and Afognak Island, Walker Rock and Husky Lakes, Afognak Island and Tuk, Afognak Island and Husky Lakes, and Tuk and Husky Lakes.

There appears to be a decrease in branchiostegal numbers with increase in latitude (Fig. 37). Walker Rock has the highest

mean which exceeds Tuk, with the lowest mean, by 0.72 rays. Tuk and Husky Lakes show that variation does exist within the same latitude with a mean difference of 0.18 rays. Samples from all four localities show frequency distribution patterns around a predominating mode of 16 (Fig. 37). The Tuk and Husky Lakes samples also show similar distribution patterns, but both differ from those of the Pacific herring in that the shift is towards smaller values. The histograms for Walker Rock and Afognak Island show little variation about the mode of 16. This mode contains most of the individuals from each locality and reflects considerable bilateral symmetry in numbers of branchiostegal rays. The histograms for Tuk and Husky Lakes have percentage distribution highs at 14 and 16. This also indicates bilateral symmetry in numbers of branchiostegal rays.

Wilder (1952) found that in brook trout (~~S.~~ Salvelinus fontinalis) the number of branchiostegal rays was smaller among fish hatched at a lower temperature than fish hatched at a higher temperature. A similar temperature effect is probably responsible for branchiostegal ray differences among the herring of this study.

Although t-tests show statistically significant differences only between Walker Rock and Tuk, percentage frequency distributions show distinctive patterns for Pacific and Arctic herring (Fig. 37).

COMPARISONS OF BODY PROPORTIONS

Proportional measurements of various body parts are commonly used to distinguish between species and infraspecific groups of fishes. Generally fish which develop in northern waters possess higher numbers of meristic parts than members of the same species from more southern latitudes. Head and fin measurements tend to be smaller in northern than in southern races. Differences in the relative sizes of body parts are mainly due to body size at growth inflection (Martin, 1949). Growth inflections are changes in the slope of the relative-growth line of a body part and delimit the different relative growth stanzas which appear during the life of a fish.

Six different characters are used in the present comparison of Pacific and Arctic herring. The head length measurements were changed to percentages of the fork length, and the measurements, length of upper jaw, snout length, postorbital length, interorbital width, and eye diameter were changed to percentages of head length. The measurements of both sexes were combined for the comparisons. Mean percentage head lengths for each five millimeter fork length group were calculated. Mean percentages of the five head length characters were calculated for each millimeter head length group. The absolute value means and the mean percentages were plotted, head length against fork length, and the five head characters against the head length, to see what differences in body proportions, if any, existed among the four samples.

1. Head length

The head length used was the actual distance from the tip of the lower jaw, with the mouth closed, to the most posterior bony edge of the operculum.

The mean head lengths, in millimeters, of four-year-old male and female Walker Rock and Tuk herring, the age class containing the largest number of specimens of known age, were calculated to determine if any differences were present between the sexes (Table XXIII).

Table XXIII. Mean head lengths (mm.) for four-year-old males and females from Walker Rock and Tuk. Numbers of fish in parentheses.

Fork length (mm.)	Walker Rock males	Walker Rock females	Walker Rock combined	Tuk males	Tuk females	Tuk combined
180-189	45.0 (1)	42.0 (1)	43.5 (2)	40.7 (6)	41.0 (3)	40.8 (9)
190-199	45.2 (8)	44.0 (1)	44.6 (9)	42.2 (5)	41.8 (17)	42.0 (22)
200-209	47.7 (6)	47.4 (8)	47.6 (14)	42.6 (7)	43.5 (15)	43.2 (22)
210-219	49.5 (2)	48.5 (2)	49.0 (4)			

In the Walker Rock sample the males tend to have slightly longer heads than do the females. The Tuk data show small and inconsistent differences between the mean head lengths of the sexes. Tester (1937a) and Jean (1945) found only small differences in percentage head lengths between sexes in Pacific and Atlantic herring respectively, and neither considered the differences sufficient to segregate the sexes for

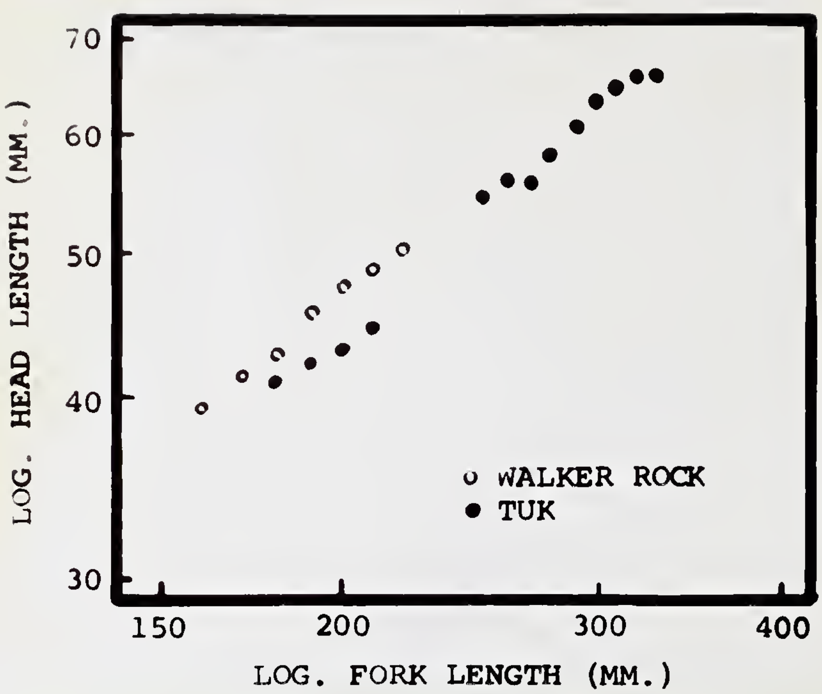

Fig. 38. Relationship of head length to fork length of herring from Walker Rock and Tuk.

comparisons. The head length measurements of both sexes were combined in the present study. Corrected fork lengths were used in the percentage head length calculations for Walker Rock, Afognak Island, and Husky Lakes to allow direct comparisons with Tuk.

The mean head lengths for each ten millimeter fork length group from Walker Rock and Tuk appear in Table XXIV.

Table XXIV. Mean head lengths (mm.) for each ten millimeter fork length group from Walker Rock and Tuk. Numbers of fish in parentheses.

Fork length (mm.)	Walker Rock	Tuk	Fork length (mm.)	Walker Rock	Tuk
160-169	39.2 (4)		260-269	-	56.0 (3)
170-179	41.1 (13)	39.0 (1)	270-279	-	55.7 (9)
180-189	42.8 (15)	41.0 (12)	280-289	-	58.7 (6)
190-199	45.7 (33)	42.0 (25)	290-299	-	60.7 (4)
200-209	47.5 (87)	43.0 (27)	300-309	-	63.1 (8)
210-219	48.7 (38)	44.5 (4)	310-319	-	64.5 (25)
220-229	50.3 (6)	47.0 (1)	320-329	-	65.5 (21)
230-239	50.0 (1)	-	330-339	-	65.9 (9)
240-249	-	-	340-349	-	67.5 (2)
250-259	-	54.5 (4)			

Figure 38 shows the increase in head length in relation to increase in fork length for Walker Rock and Tuk. Fork length groups with ~~less~~ fewer than three individuals were not plotted. The samples show that at equal fork lengths the herring from Walker Rock have longer heads than the herring from Tuk.

Head lengths means, expressed as percentages of the fork lengths, were calculated for each five millimeter fork length group from the four localities investigated (Table XXV).

Table XXV. Mean head length as a percentage of fork length in each five millimeter fork length group in samples from Walker Rock, Afognak Is., Tuk, and Husky Lakes. Numbers of fish in parentheses.

Fork length in mm.	Walker Rock	Afognak Is.	Tuk	Husky Lakes
155-159				
160-164	23.70 (2)			
165-169	23.90 (2)			
170-174	23.61 (7)			
175-179	23.55 (6)		21.79 (1)	
180-184	23.25 (9)		22.00 (2)	
185-189	23.23 (6)		22.00 (10)	
190-194	23.45 (9)		21.45 (9)	
195-199	23.31 (24)		21.46 (16)	
200-204	23.14 (29)		21.26 (22)	
205-209	23.17 (58)	22.46 (2)	21.20 (5)	
210-214	22.90 (25)	23.26 (3)	20.07 (3)	
215-219	22.78 (13)		20.90 (1)	
220-224	22.57 (4)		21.40 (1)	
225-229	22.40 (2)	20.35 (1)		
230-234	21.40 (1)	21.45 (1)		
235-239		19.74 (1)		21.30 (4)
240-244		20.16 (2)		21.39 (1)
245-249				21.10 (3)
250-254			21.90 (1)	21.03 (1)
255-259			21.33 (3)	21.43 (2)
260-264			21.20 (1)	21.21 (3)
265-269			21.00 (2)	21.08 (2)
270-274			20.52 (7)	21.05 (3)
275-279		19.92 (1)	19.95 (2)	
280-284			20.65 (4)	21.16 (3)
285-289		20.90 (1)	20.85 (2)	
290-294			20.20 (1)	
295-299			20.57 (3)	
300-304			20.82 (4)	
305-309			21.57 (4)	
310-314			20.54 (14)	
315-319			20.34 (12)	
320-324			20.31 (10)	
325-329			20.09 (11)	
330-334			20.38 (5)	
335-339			20.38 (4)	
340-344			19.70 (2)	

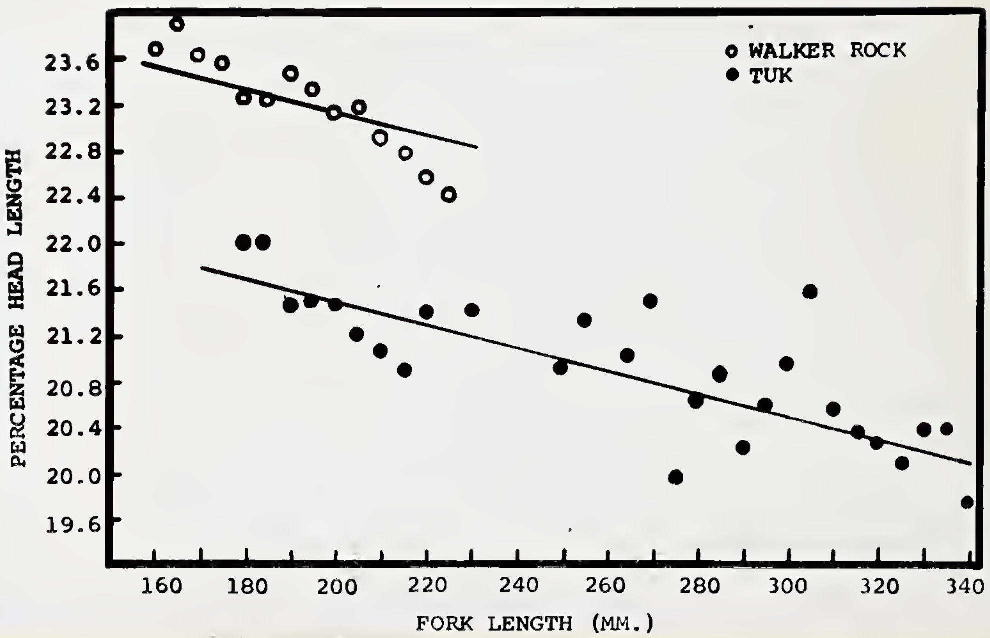

Fig. 39. Mean percentages head lengths of fork lengths for herring from Walker Rock and Tuk.

The data appear in Figure 39 in which each point represents the mean percentage head length for the fork length group designated on the x-axis. Regression lines were calculated for Walker Rock and Tuk using only those fork length groups containing nine or more fish. The regression lines were found to have the same slopes. The negatively sloping lines for both samples show that the percentage head length decreases with increase in fork length of the herring. The graph also shows that the heads of the Walker Rock herring are about 1.6 percent larger than the heads of Tuk herring. The head length percentages of Husky Lakes were found to resemble closely those of Tuk, whereas the head length percentages of the small Afognak Island sample tend to resemble those of Walker Rock. Both Husky Lakes and Afognak Island samples show a decrease in percentage head length with increase in fork length. The head length increases as the fish grows, but at a slower rate than the body (bradyauxesis). Equal rates of increase in head and fork length would appear in Figure 39 as a horizontal line showing a constant relationship between the two variables. Rounsefell (1930) and Tester (1937a) showed that in both Alaska and British Columbia herring there is a decrease in mean percentage head length with increase in body length. The results of the present study corroborate these statements and also show that the herring from Tuk and Husky Lakes are characterized by a similar relationship.

Mean percentage head lengths were calculated for herring of

different fork lengths within the four-year-old group from Walker Rock and Tuk (Table XXVI).

Table XXVI. Mean percentage head lengths for various fork lengths of four-year-old herring from Walker Rock and Tuk. Numbers of fish in parentheses.

Fork length (mm.)	Walker Rock	Tuk
180-189	24.17 (2)	22.67 (9)
190-199	23.68 (9)	22.10 (22)
200-209	23.80 (14)	21.60 (22)
210-219	23.57 (4)	-

The data show that within the four-year-old group the longer, faster growing fish have relatively smaller heads than the shorter, slow growing fish. Four-year-old herring were compared in the present study because this age group contains the largest number of specimens of known age from Walker Rock and Tuk. Tester (1937a) showed a similar head length-body length relationship in British Columbia herring and concluded that it was necessary to compare fish of the same age when determining differences in head lengths between populations because of the overlap in body lengths among different ages.

Rounsefell (1930) showed among Pacific herring the presence of a general decrease in percentage head length from south to north and west. The Tuk and Husky Lakes herring have smaller heads than

those from Walker Rock. The differences in percentage head length between the Pacific and Arctic samples in this study are sufficient to distinguish between the two areas. However, Rounsefell (1930) found that percentage head lengths, expressed as percentages of total length, of various populations of herring from south-central Alaska ranged from 22.4 percent at 180 millimeters to 19.2 percent at 310 millimeters. If total length had been used instead of fork length in the present study, the head length percentages would have been still smaller, but despite the different measurements used, the percentage head length range of Rounsefell's south-central Alaska herring encloses the ranges from Tuk and Husky Lakes. Although percentage head length differences can be used to distinguish between populations of herring from different localities, they cannot be used to separate Pacific and Arctic herring because of the existing overlap in the percentage head length ranges of some Alaskan Pacific and Canadian Arctic herring.

2. Upper jaw

The length of the upper jaw used is the distance from the most anterior part of the premaxillary to the most posterior part of the maxillary. The mean upper jaw lengths for each five millimeter head length group from Walker Rock and Tuk appear in Table XXVII.

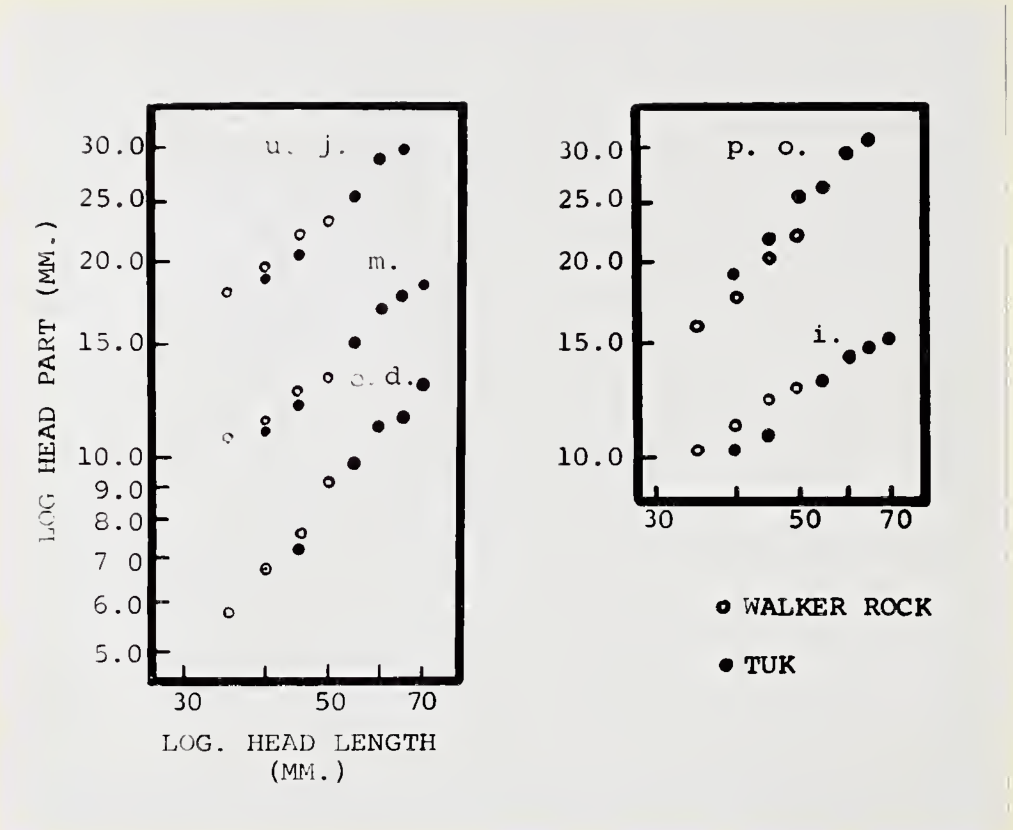

Fig. 40. Log of various head measurements plotted against log of head length.

Table XXVII. Mean upper jaw lengths (mm.) for each five millimeter head length group from Walker Rock and Tuk. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Tuk
35-39	18.0 (3)	17.0 (1)
40-44	19.8 (36)	18.9 (60)
45-49	22.1 (138)	20,6 (9)
50-54	23.3 (20)	24.0 (2)
55-59	-	25.3 (20)
60-64	-	29.0 (26)
65-69	-	30.0 (40)
70-74	-	31.5 (3)

The relationship between upper jaw length and head length for Walker Rock and Tuk appears in Figure 40. Only groups containing three or more individuals were plotted. The data show that at equal head lengths up to 45 millimeters, the herring from the Walker Rock sample have longer upper jaws than the herring from the Tuk sample.

Upper jaw lengths, expressed as percentages of the head lengths, were averaged for each millimeter head length group from the four localities investigated (Table XXVIII). The percentage upper jaw lengths for Walker Rock and Tuk appear in Figure 41. The distributions of points in the scatter diagram show that the Walker Rock herring possess a consistently longer upper jaw length, expressed as a percentage of head length, than do the Tuk herring. Both sets of points are scattered in a manner characterizing horizontal lines. Regression lines were calculated for Walker Rock using points representing four or more individuals, and for Tuk using groups containing nine or more individuals. The lines for Walker Rock

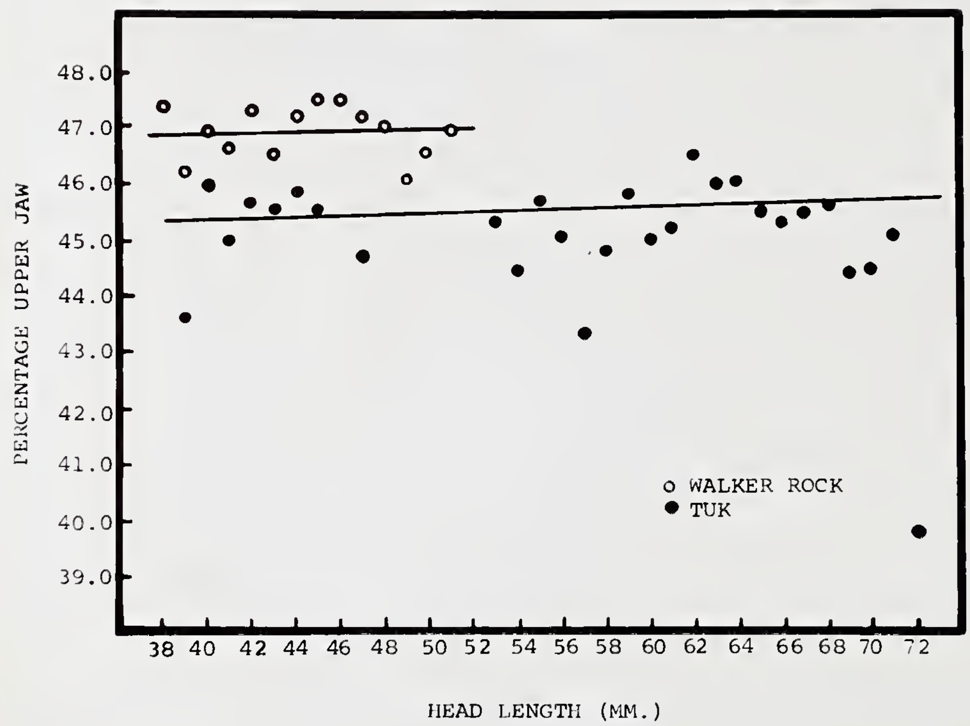

Fig. 41. Mean percentages upper jaw of head lengths for herring from Walker Rock and Tuk.

Table XXVIII. Mean upper jaw length as percentage of head length in each one millimeter head length group for the four localities investigated. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Afognak Is.	Tuk	Husky Lakes
38	47.40 (1)			
39	46.20 (2)		43.60 (1)	
40	46.87 (4)		46.00 (5)	
41	46.58 (8)		44.99 (15)	
42	47.30 (9)		45.65 (17)	
43	46.50 (6)		45.55 (18)	
44	47.18 (9)		45.86 (5)	
45	47.48 (14)		45.55 (8)	
46	47.52 (16)	47.83 (2)		
47	47.24 (38)	46.81 (2)	44.70 (1)	
48	47.00 (49)	48.96 (2)		
49	46.05 (21)	48.98 (1)		46.94 (1)
50	46.53 (15)	46.00 (2)		44.00 (1)
51	46.88 (5)			45.10 (1)
52		44.23 (1)		45.51 (3)
53			45.30 (1)	47.17 (3)
54			44.40 (1)	46.30 (1)
55		47.27 (1)	45.67 (7)	45.45 (1)
56			45.05 (4)	45.83 (3)
57			43.16 (5)	45.03 (3)
58			44.80 (1)	48.28 (2)
59			45.80 (3)	46.62 (2)
60		45.00 (1)	45.00 (1)	46.67 (1)
61			45.10 (2)	
62			46.46 (5)	
63			46.00 (7)	
64			46.03 (11)	
65			45.49 (16)	
66			45.26 (10)	
67			45.44 (7)	
68			45.60 (5)	
69			44.20 (2)	
70			44.30 (1)	
71			45.10 (1)	
72				
73			39.80 (1)	

and Tuk have a small positive slope which indicates that the upper jaws increase in length at a slightly greater rate than the head length (tachyauxesis). The percentage upper jaw lengths differ between the two samples by about 1.4 percent over the comparable range of head lengths. The data from Afognak Island and Husky Lakes also show a tendency for the percentage upper jaw to remain relatively constant over the various head lengths represented. The sample from Husky Lakes possesses only slightly greater percentage upper jaw lengths than the sample from Tuk. The sample from Afognak Island more closely resembles Walker Rock than Tuk over the head length range from 46 to 50 millimeters.

The herring samples from Walker Rock and Tuk can be distinguished by differences in percentage upper jaw lengths, but no generalization on use of this character in diagnosis of Pacific and Arctic herring can be made because the percentage upper jaw lengths from Husky Lakes fall between the ranges of Walker Rock and Tuk.

3. Snout length

The snout length used is the distance from the most anterior part of the snout to the most anterior bony rim of the orbit of the eye. The mean snout lengths for each five millimeter head length group from Walker Rock and Tuk appear in Table XXIX. These data are plotted in Figure 40.

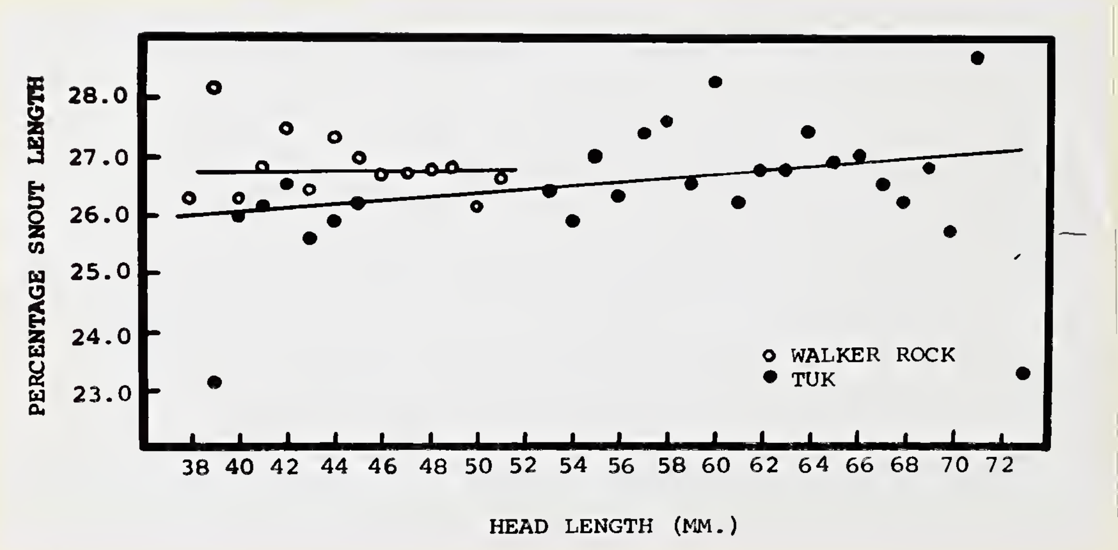

Fig. 42. Mean percentages snout length of head lengths for herring from Walker Rock and Tuk.

Table XXIX. Mean snout lengths (mm.) for each five millimeter head length group from Walker Rock and Tuk. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Tuk
35-39	10.7 (3)	11.0 (1)
40-44	11.4 (36)	11.0 (60)
45-49	12.7 (138)	12.0 (9)
50-54	13.3 (20)	14.0 (2)
55-59	-	15.0 (20)
60-64	-	17.0 (26)
65-69	-	17.7 (40)
70-74	-	18.5 (3)

The samples from Walker Rock and Tuk show an increase in snout length with increase in head length. Comparisons of the snout length means at head lengths of 40 and 45 millimeters, the head length groups containing the most individuals, show that the snout lengths from Walker Rock are slightly larger than those from Tuk.

Snout lengths, expressed as percentages of the head lengths, were averaged for each millimeter head length group from the four localities investigated (Table XXX). The percentage snout lengths for Walker Rock and Tuk appear in Figure 42. The scatter diagram for Walker Rock does not show any well-formed trend, but the calculated regression line, based on points representing four or more individuals, has a very small positive slope. The scatter diagram and regression line for the Tuk sample show the presence of a slight increase in percentage snout length with increase in head length.

Table XXX. Mean snout length as percentage of head length in each one millimeter head length group for the four localities investigated. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Afognak Is.	Tuk	Husky Lakes
38	26.30 (1)			
39	28.20 (2)		23.10 (1)	
40	26.25 (4)		26.00 (5)	
41	26.80 (8)		26.16 (15)	
42	27.53 (9)		26.48 (17)	
43	26.36 (6)		25.60 (18)	
44	27.30 (9)		25.92 (5)	
45	27.01 (14)		26.20 (8)	
46	26.65 (16)	26.09 (2)		
47	26.71 (38)	25.53 (2)	25.53 (1)	
48	26.80 (49)	27.08 (2)		
49	26.80 (21)	28.57 (1)		26.53 (1)
50	26.13 (15)	26.00 (2)		26.00 (1)
51	26.64 (5)			27.45 (1)
52		25.00 (1)		25.64 (3)
53			26.40 (1)	27.05 (3)
54			25.90 (1)	25.93 (1)
55		27.27 (1)	27.02 (7)	27.27 (1)
56			26.35 (4)	26.19 (3)
57			27.38 (5)	26.32 (3)
58			27.60 (1)	27.59 (2)
59			26.53 (3)	27.12 (2)
60		25.00 (1)	28.30 (1)	26.67 (1)
61			26.20 (2)	
62			26.76 (5)	
63			26.77 (7)	
64			27.41 (11)	
65			26.94 (16)	
66			27.00 (10)	
67			26.47 (7)	
68			26.20 (5)	
69			26.80 (2)	
70			25.70 (1)	
71			28.70 (1)	
72				
73			23.30 (1)	

The positive slopes for Walker Rock and Tuk indicate that the snout increases in length proportionately faster than the head. The snout length percentages of Walker Rock are somewhat greater than those of Tuk over the comparable head length range from 39 to 45 millimeters. The differences between Walker Rock and Tuk are small, but may be considered of value in distinguishing between the two samples. The snout length percentages from Husky Lakes show a slight upward trend with increase in head length. The data from Afognak Island are scanty, but the herring around a head length of 50 millimeters have a percentage snout length of approximately 26 percent. This is very similar to those from the other localities at the same length.

Jean (1945) found consistent differences in this character between two populations of herring from the Gulf of St. Lawrence. On the basis of the variation of the snout lengths over the head length ranges of the herring from the four samples investigated, this character is valuable in distinguishing between some local populations, but is of no value in distinguishing between Pacific and Arctic herring.

4. Postorbital length

The postorbital length used was the distance from the edge of the posterior bony orbit of the eye to the most posterior bony edge of the operculum. The mean postorbital lengths for each of

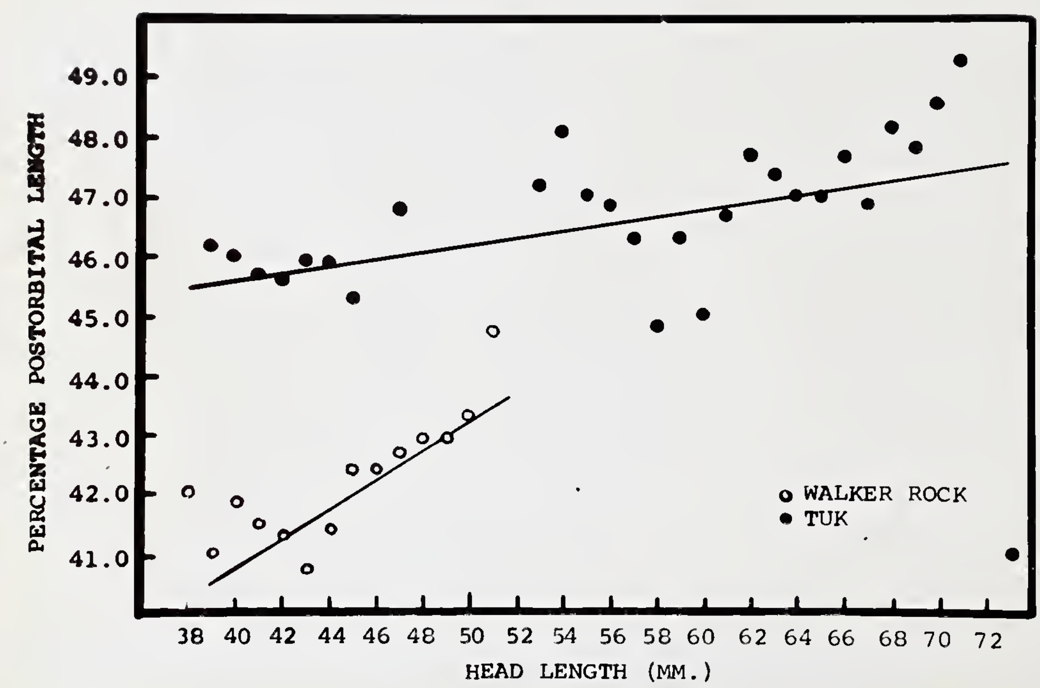

Fig. 43. Mean percentages postorbital length of head lengths for herring from Walker Rock and Tuk.

the five millimeter head length groups from Walker Rock and Tuk appear in Table XXXI and are represented in Figure 40.

Table XXXI. Mean postorbital lengths (mm.) for each five millimeter head length group from Walker Rock and Tuk. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Tuk
35-39	16.3 (3)	18.0 (1)
40-44	17.6 (36)	19.2 (60)
45-49	20.1 (138)	21.6 (9)
50-54	22.0 (20)	25.5 (2)
55-59	-	26.3 (20)
60-64	-	29.7 (26)
65-69	-	31.3 (39)
70-74	-	34.5 (3)

Both Walker Rock and Tuk samples show an increase in postorbital length with increase in head length. The herring from Tuk consistently have greater postorbital lengths, for equal head lengths, than the herring from Walker Rock.

Mean postorbital lengths, expressed as percentages of the head lengths, were calculated for each one millimeter head length group from the four localities investigated (Table XXXII). These data appear in Figure 43.

The scatter diagrams and regression lines distinctly separate the samples from Walker Rock and Tuk. Both samples have positive sloping lines with Walker Rock showing a steeper slope than Tuk.

Table XXXII. Mean postorbital length as percentage of head length in each one millimeter head length group for the four localities investigated. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Afognak Is.	Tuk	Husky Lakes
38	42.00 (1)			
39	41.00 (2)		46.20 (1)	
40	41.87 (4)		45.98 (5)	
41	41.50 (8)		45.67 (15)	
42	42.61 (9)		45.62 (17)	
43	40.68 (6)		45.86 (18)	
44	41.41 (9)		45.86 (5)	
45	42.36 (14)		45.27 (8)	
46	42.40 (16)	43.48 (2)		
47	42.67 (38)	44.68 (2)	46.80 (1)	
48	42.90 (49)	43.75 (2)		
49	42.86 (21)	44.90 (1)		44.90 (1)
50	43.33 (15)	45.00 (2)		44.00 (1)
51	44.70 (5)			45.10 (1)
52		46.15 (1)		45.51 (3)
53			47.20 (1)	45.28 (3)
54			48.10 (1)	44.44 (1)
55		45.45 (1)	47.02 (7)	45.45 (1)
56			46.85 (4)	44.64 (3)
57			46.32 (5)	45.03 (3)
58			44.80 (1)	46.55 (2)
59			46.33 (3)	42.37 (2)
60			45.00 (1)	45.00 (1)
61			46.70 (2)	
62			47.74 (5)	
63			47.37 (7)	
64			47.03 (11)	
65			47.04 (16)	
66			47.65 (9)	
67			46.92 (7)	
68			48.22 (5)	
69			47.80 (2)	
70			48.60 (1)	
71			49.30 (1)	
72				
73			41.10 (1)	

The Tuk sample has higher postorbital percentage lengths by three to four percent than the Walker Rock sample. The positive regression slopes indicate that the postorbital length increases proportionately faster than the head length for both Walker Rock and Tuk samples. The postorbital length increases more rapidly among Walker Rock than among Tuk herring. The percentage postorbital lengths for Husky Lakes resemble Tuk, but have slightly lower mean percentage values. The Afognak Island mean percentages fall between those of Walker Rock and Tuk.

The percentage postorbital lengths show a general increase from south to north. This character is useful in distinguishing between some local populations of herring, but is of limited value in distinguishing between Pacific and Arctic herring.

5. Eye diameter

The eye diameter used was the greatest antero-posterior distance between the bony orbital rims of the eyes. The mean eye diameters for each five millimeter head length group were calculated for Walker Rock and Tuk (Table XXXIII) and appear in Figure 40.

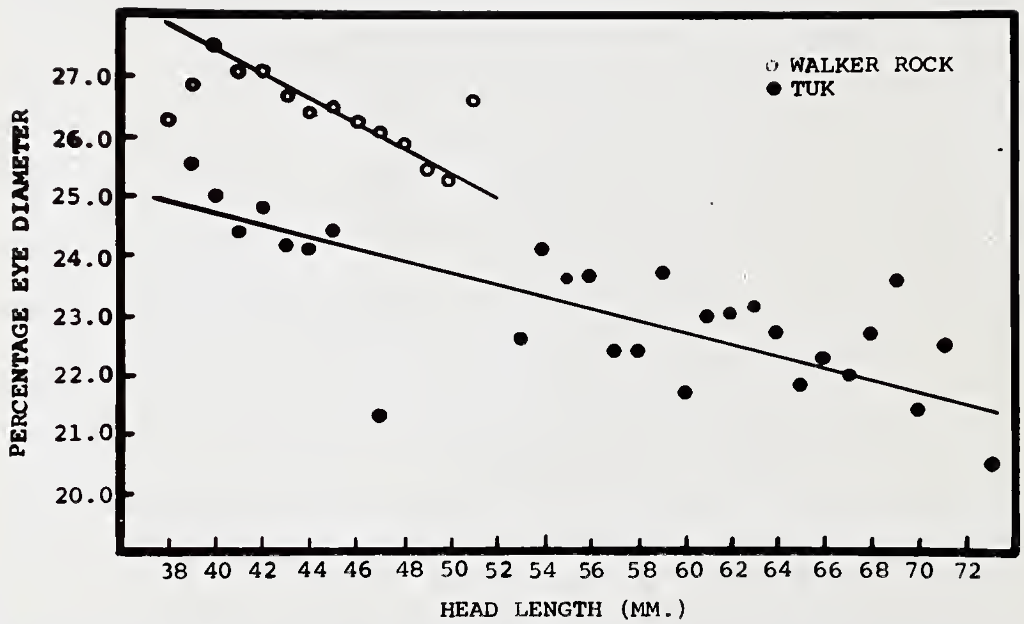

Fig. 44. Mean percentages eye diameter of head lengths for herring from Walker Rock and Tuk.

Table XXXIII. Mean eye diameters (mm.) for each five millimeter head length group from Walker Rock and Tuk. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Tuk
35-39	10.3 (3)	10.0 (1)
40-44	11.4 (36)	10.3 (60)
45-49	12.3 (138)	10.9 (9)
50-54	12.9 (20)	12.5 (2)
55-59	-	13.2 (20)
60-64	-	14.3 (26)
65-69	-	14.8 (40)
70-74	-	15.3 (3)

The means show that there is an increase in eye diameter with increase in head length in both Walker Rock and Tuk samples. Walker Rock herring have larger eye diameters than Tuk herring of similar head lengths.

Mean eye diameters, expressed as percentages of the head length, were calculated for each one millimeter head length group from the four localities investigated (Table XXXIV) and appear in Figure 44. Scatter diagrams and negatively sloping lines separate the samples from Walker Rock and Tuk. Walker Rock herring possess larger eyes per head length than Tuk herring. The average difference between Walker Rock and Tuk over the head length range from 39 to 45 millimeters is approximately 2.5 percent. The percentage eye diameters decrease with increased head lengths in both Walker Rock and Tuk samples. This indicates that the eye diameter increases in size

Table XXXIV. Mean eye diameter as a percentage of head length in each one millimeter head length group for the four localities investigated. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Afognak Is.	Tuk	Husky Lakes
38	26.30 (1)			
39	26.90 (2)		25.60 (1)	
40	27.50 (4)		25.00 (5)	
41	27.12 (8)		24.40 (15)	
42	27.08 (9)		24.79 (17)	
43	26.73 (6)		24.13 (18)	
44	26.40 (9)		24.08 (5)	
45	26.52 (14)		24.40 (8)	
46	26.24 (16)	26.09 (2)		
47	26.11 (38)	25.53 (2)	21.30 (1)	
48	25.90 (49)	27.08 (2)		
49	25.45 (21)	26.53 (1)		24.49 (1)
50	25.33 (15)	26.00 (2)		24.00 (1)
51	26.64 (5)			25.49 (1)
52		25.00 (1)		23.72 (3)
53			22.60 (1)	23.29 (3)
54			24.10 (1)	24.07 (1)
55		27.27 (1)	23.60 (7)	23.64 (1)
56			23.65 (4)	24.40 (3)
57			22.44 (5)	23.39 (3)
58			22.40 (1)	23.78 (2)
59			23.70 (3)	23.73 (2)
60		25.00 (1)	21.70 (1)	23.33 (1)
61			23.00 (2)	
62			23.00 (5)	
63			23.11 (7)	
64			22.71 (12)	
65			21.83 (16)	
66			22.25 (10)	
67			21.97 (7)	
68			22.66 (5)	
69			23.55 (2)	
70			21.40 (1)	
71			22.50 (1)	
72				
73			20.50 (1)	

proportionately more slowly than the head length. The percentage eye diameters of Husky Lakes closely resemble those of Tuk, and also show a decrease in value with increased head lengths. The Afognak Island percentage eye diameters more closely resemble those of Walker Rock than Tuk.

The differences in percentage eye diameters readily distinguish between the samples of herring from Walker Rock and Tuk. Percentage eye diameters also show that the samples of herring from the Pacific Ocean resemble each other more closely than they resemble herring from Arctic waters, and that samples from the Arctic resembled each other more closely than they do samples from the Pacific Ocean. The eye diameter may therefore be considered a valuable character to assist in distinguishing between Pacific and Arctic herring.

6. Interorbital width

The interorbital width used is the distance between the dorsal orbital rims immediately above the centers of the pupils. The mean interorbital widths for each of the five millimeter head length groups for Walker Rock and Tuk appear in Table XXXV and are represented in Figure 40.

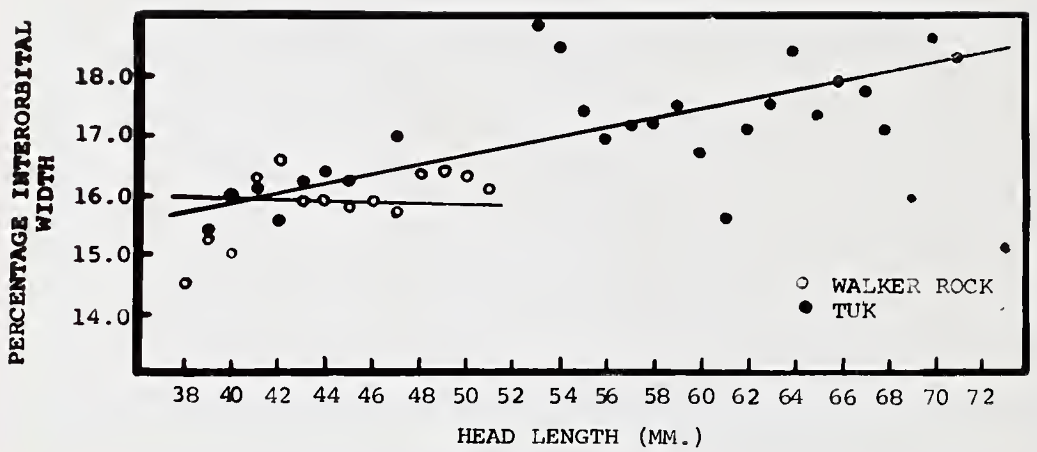

Fig. 45. Mean percentages interorbital width of head lengths for herring from Walker Rock and Tuk.

Table XXXV. Mean interorbital width (mm.) for each five millimeter head length group from Walker Rock and Tuk. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Tuk
35-39	5.8 (3)	7.0 (1)
40-44	6.7 (36)	6.7 (60)
45-49	7.6 (138)	7.2 (9)
50-54	9.2 (20)	10.0 (2)
55-59	-	9.8 (20)
60-64	-	11.1 (26)
65-69	-	11.5 (40)
70-74	-	13.0 (3)

Samples from both Walker Rock and Tuk showed increased interorbital widths with increased head lengths, but neither sample was characterized by a consistently higher mean.

Mean interorbital widths, expressed as percentages of the head length, were calculated for each one millimeter head length group from the four localities investigated (Table XXXVI). These data are plotted in Figure 45.

The scatter diagram for Walker Rock shows a definite trend for the percentage interorbital lengths to increase with increases in head length. The regression line, based on groups containing four or more individuals, has a very small negative slope, but this does not correctly represent the trend of the whole sample, because it considers only the interorbital width values for certain head lengths. The Walker Rock percentage interorbital widths tend

Table XXXVI. Mean interorbital width as a percentage of head length in each one millimeter head length group for the four localities investigated. Numbers of fish in parentheses.

Head length (mm.)	Walker Rock	Afognak Is.	Tuk	Husky Lakes
38	14.50 (1)			
39	15.40 (2)		15.40 (1)	
40	15.00 (4)		16.00 (5)	
41	16.16 (8)		16.09 (15)	
42	16.56 (9)		15.57 (17)	
43	15.92 (6)		16.17 (18)	
44	15.90 (9)		16.36 (5)	
45	15.83 (14)		16.15 (8)	
46	15.89 (16)	15.22 (2)		
47	15.67 (38)	14.89 (2)	17.00 (1)	
48	16.25 (49)	15.62 (2)		
49	16.40 (21)	18.37 (1)		16.33 (1)
50	16.27 (15)	17.00 (2)		16.00 (1)
51	16.08 (5)			15.69 (1)
52		15.38 (1)		15.38 (3)
53			18.90 (1)	16.98 (3)
54			18.50 (1)	16.67 (1)
55		18.16 (1)	17.42 (7)	16.36 (1)
56			16.98 (4)	16.67 (3)
57			17.16 (5)	16.37 (3)
58			17.20 (1)	17.24 (2)
59			17.47 (3)	16.95 (2)
60		16.67 (1)	16.70 (1)	16.67 (1)
61			15.60 (2)	
62			17.06 (5)	
63			17.47 (7)	
64			18.36 (11)	
65			17.31 (16)	
66			17.90 (10)	
67			17.68 (7)	
68			17.04 (5)	
69			15.90 (2)	
70			18.60 (1)	
71			18.30 (1)	
72				
73			15.10 (1)	

to be smaller than those from Tuk. The scatter diagram and regression line for Tuk show an increase in percentage interorbital length with increase in head length. The positive slope to the Tuk line indicates that the interorbital width increases proportionately faster than the head length. In the head length range from 38 to 50 millimeters, the samples from both Walker Rock and Tuk have percentage interorbital width values around 16 percent. Interorbital width values for Tuk herring at head lengths of 56 to 66 millimeters vary from 17 to 18 percent of the head length. The Husky Lakes data show an increase in percentage interorbital width with increased head length, percentage values slightly smaller than those of Tuk. The Afognak Island data also show an increase in percentage interorbital widths with increased head lengths, but no conclusions regarding relationships to either Walker Rock or Tuk can be drawn because of the small amount of Afognak Island data.

The interorbital width measurements were taken only to the nearest millimeter and on this basis the data can reveal only general trends in relationships between the character and head length. The interorbital width varies little among the samples of herring investigated, but it is of some value in distinguishing between some populations.

SUMMARY AND CONCLUSIONS

Comparisons of meristic characters and body proportions show that the herring from the Arctic waters of Canada are similar to those from the Pacific Ocean. Pacific Clupea are known to exist as local populations which possess characteristics which distinguish them from other such populations. The four samples used in this study were taken from four different localities, two from the Pacific Ocean (Walker Rock and Afognak Island) and two from the waters of Arctic Canada (Tuk and Husky Lakes).

The author attempted to determine which characters could be used to distinguish between the various samples and which characters, if any, could be used to distinguish between Pacific and Arctic herring. The results of t-tests comparing the means of the various meristic characters may be summarized as follows where S = significant difference and NS = non-significant difference at the one percent probability level; Walker Rock--W. R., Afognak Island--Af. Is., Tuk, and Husky Lakes--H. L.

	W. R.- Af. Is.	W. R.- Tuk	W. R.- H. L.	Af. Is.- Tuk	Af. Is.- H. L.	Tuk H. L.
Total V.	S	S	S	NS	NS	S
A. V.	NS	S	S	S	S	NS
C. V.	NS	NS	NS	NS	NS	NS
Scales K.	S	S	S	S	NS	S
Scales L.	NS	S	S	S	S	NS
Scales D.	NS	S	NS	NS	NS	NS
Scales V.	NS	NS	NS	NS	NS	NS
G. Ra.	S	S	S	NS	NS	NS
D. fin	NS	NS	NS	NS	NS	NS
A. fin	NS	NS	S	NS	S	S
Pt. fin	S	S	S	NS	NS	S
Pl. fin	NS	NS	S	NS	S	S
Br.	NS	S	NS	NS	NS	NS

Mean numbers of caudal vertebrae, ventral scales and dorsal fin rays were found to be of no use in distinguishing between or among Pacific and Arctic samples. Mean numbers of total vertebrae, "keel" scales, dorsal scales, gill rakers, anal fin rays, pectoral fin rays, pelvic fin rays, and branchiostegal rays were found useful to distinguish between herring from different localities, but of no value in distinguishing between Pacific and Arctic herring. Mean numbers of abdominal vertebrae and lateral line scales differed significantly between Pacific and Arctic samples and may be considered useful to distinguish between herring from the two areas.

Interorbital width and upper jaw, each expressed as a percentage of head length, differed slightly among the herring from the four localities. Head lengths, expressed as a percentage of fork length, as well as lengths of upper jaw, snout, and ~~inter~~ post orbital width, expressed as percentages of head lengths were useful in distinguishing between Walker Rock and Tuk but of no value in separating Pacific and Arctic herring generally because the sample from Alaska closely resembled those of Arctic Canada. The percentage eye diameter was found useful in distinguishing between Arctic and Pacific herring.

Arctic herring possess smaller first year scale "diameters" than Pacific herring. Herring from Tuk mature at six years whereas Pacific herring mature at an earlier age.

Herring from northern waters tend to possess higher numbers of meristic parts than herring from more southern latitudes. Mean numbers of total vertebrae, abdominal vertebrae, "keel" scales, lateral line scales, and gill rakers show such latitudinal clines. Mean numbers of branchiostegal and pectoral fin rays tend to decrease with increase in latitude. Herring from northern waters possess relatively smaller heads, upper jaws, snout lengths, and eye diameters, but relatively larger postorbital lengths and interorbital widths than herring from southern waters.

Comparisons of meristic characters and body proportions show that the herring from Arctic Canada are very similar to those from the Pacific Ocean and, although differences in scale "diameter" at end of first year, meristic counts and body proportions, probably attributable to environmental conditions during early development, do exist between the two areas, no consistent pattern of difference can be made out between Pacific and Arctic *Clupea* generally. The herring from Arctic Canada may be considered the same subspecies as the herring from the North Pacific Ocean, *Clupea harengus pallasi* Val.

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APPENDIX A

Notes on water conditions at Tuk, N. W. T., from August 31 to September 10, 1958.

In 1958 the ice broke up at Tuk on June 21, slightly earlier than the usual breakup which may occur from around the end of June to the first week in July.

The water from the Mackenzie River considerably affects the salinity of the water at Tuk. Local inhabitants report that a general increase in "saltiness" of the water occurs as the summer progresses. Presumably this is the result of a decreasing amount of flow of Mackenzie water into the sea. A. Sherwood determined the salinities of three water samples by titration with silver nitrate using dichlorofluorescein as an indicator. Salt ion concentration, expressed as grams of sodium chloride per liter of solution were: August 30--3.47 $\pm$ 0.01, September 8--3.46 $\pm$ 0.01, and September 10--3.20 $\pm$ 0.01. The decrease in salinity on September 10 followed three days of strong west winds accompanied by about 13 millimeters of rainfall. The water became less turbid from August 31 to September 6 with Secchi disc readings increasing from 43 to 48 centimeters. The entrance to the bay at Tuk faces the northwest and strong winds from this direction can raise the water level and increase the turbidity. Following the three days of west wind previously mentioned, the Secchi disc reading decreased to 30 centimeters. The percentage of *Clupea* in the total catch of fishes decreased with the increase in turbidity and decrease in salinity. The effects of the tide is felt only slightly with the water levels fluctuating about one foot. No ice was observed during the 11 days spent at Tuk.

APPENDIX B

Other species of fish netted with *Clupea* at Tuk

Other species of fish caught in gill nets during August 31 to September 10, 1958, with the *Clupea* included the following (after McAllister, 1960):

Oncorhynchus gorbuscha (Walbaum)--pink salmon

Salvelinus alpinus (Linnaeus)--Arctic char

Coregonus albula (Linnaeus)--least herring

Coregonus clupeaformis (Mitchill)--lake whitefish

Coregonus kennicotti Milner--broad whitefish

Coregonus oxyrhynchus (Linnaeus)--lauretta herring

Stenodus leucichthys nelma (Pallas)--inconnu

Osmerus eperlanus (Linnaeus)--rainbow smelt

Esox lucius Linnaeus--pike

Eleginus navaga (Pallas)--saffron cod

Lota lota (Linnaeus)--burbot

Cottidae (sp.?)

Liopsetta glacialis (Pallas)--Arctic flounder

Platichthys stellatus (Pallas)--starry flounder

One Arctic lamprey, *Entosphenus japonicus* (Martens), was captured while attached to a *Clupea*.

APPENDIX C

Lamprey parasitism on fishes at Tuk

The Arctic lamprey, Entosphenus japonicus (Martens), ranges from the White Sea of Europe east to the Mackenzie River and Great Slave Lake in Canada. The author found ammocoetes in the stomachs of inconnu taken at Whitefish Station on the east side of the mouth of the Mackenzie River in August, 1956. Numerous lamprey-scarred fish were observed in native nets at Tuk from August 31 to September 10, 1958. Eskimos reported lampreys frequently attached to netted fish during the last week of August. On August 31 the author visited eight native nets set in various parts of the bay at Tuk. The nets usually used by the Eskimos here have a stretched mesh size of three and one-half inches and are approximately 20 yards long. The catch was made up mostly of lauretta herring, broad or round-nosed whitefish, and a few hump-backed whitefish and least herring. Of six Clupea removed from these nets, three were lamprey scarred. Five lampreys were encountered attached to netted fish, most of which were lauretta and least herring. The author estimates that approximately one of every 15 netted fish bore lamprey marks. Very sensitive to net movement, any lampreys attached to netted fish quickly released their grip on the hosts and swam free as the nets were brought to the surface. The lampreys were bright and silvery in color and approximately 12 to 16 inches in length.

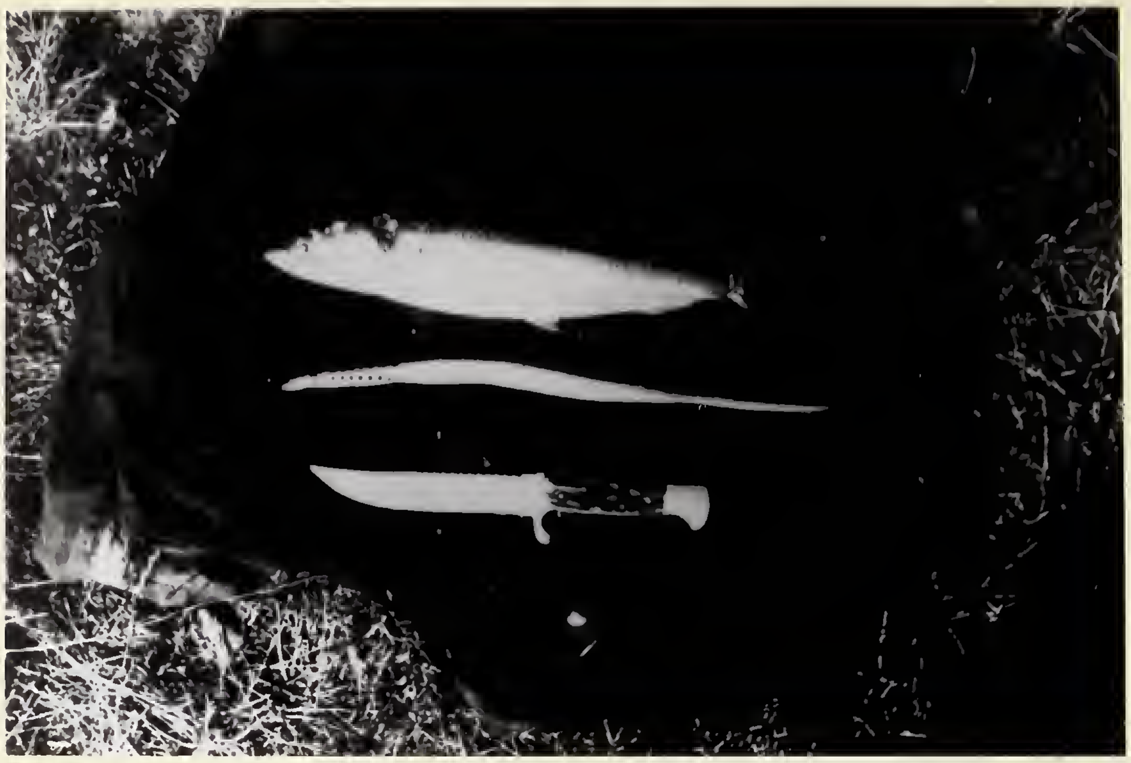

Fig. 46. Herring (310 mm.) and parasitic lamprey from Tuk, N. W. T., September 3, 1958. Note scars on host.

Fig. 47. Net-caught herring (328 mm.) from Tuk, N. W T., August 31, 1958, showing severe lamprey scars.

On September 3 an Eskimo fisherman, J. Nasogaluak, with whom the author traded several hundred whitefish for a considerably smaller number of Clupea, captured a lamprey attached to a netted Arctic herring. A photograph of the herring and lamprey is shown in Figure 46. Figure 47 shows a herring bearing severe lamprey scars, one of which penetrated the body wall. The percentage frequency of lamprey attacks on the fishes observed decreased during the period of time from September first to tenth. Table XXXVII gives the frequency of lamprey attacks on netted Clupea.

Table XXXVII. Frequency of lamprey attacks on netted herring from Tuk, August 31 to September 10, 1958.

Date	Number of Clupea examined	Number of scarred fish	%
August 31	6	3	50
September 1	3	0	0
2	16	0	0
3	6	1	17
4	24	0	0
5	4	0	0
6	10	0	0
7	35	1	3
8	36	2	2
9	3	0	0
10	18	0	0

APPENDIX D

Data sheets

The data for the counts and measurements of the herring specimens used in this study appear on the following pages:

pages 110 to 129	Walker Rock	December 3, 1958
pages 130 to 146	Tuk	August 31 to September 10, 1958
pages 147 to 149	Husky Lakes	August 26, 1955
page 149	Tuk	August 6, 1955

Royal Ontario Museum specimen numbers, localities, and dates of capture follow:

pages 150 to 151	10271	Tuk	August 24, 1937
	10911	Kidluit	September 3, 1938
	10920	Kidluit	September 4, 1938
	10921	"	"
	10922	"	"
	10923	"	"
	15103	Bathurst Inlet	August 1 to 14, 1950
	15104	"	"
	15425	Tuk	September 13 and 21, 1951
	15426	"	"
	15427	"	"
	15428	"	"
	15490	Yukon	"

Of 211 herring caught at Tuk in 1958, 162 were preserved. Tuk fork length and weight data are from freshly caught specimens. Other fork length and weight data in this appendix are of preserved specimens.

WALKER ROCK

Number	178	187	177	192	179	193	176	183	172
Sex	♂	♀	♂	♂	♀	♂	♀	♀	♀
Age	6	4	6	6	5	-	-	7	6
Wt.	96	90	104	90	82	94	126	82	86
F. L.	210	203	211	205	198	203	216	194	203
H. L.	50	48	49	47	42	49	51	47	49
u. j.	23	23	24	23	23	22	23	22	22
m.	13	13	13	12	12	13	13	13	13
p. o.	21	20	21	20	20	21	24	20	22
e. d.	13	13	13	13	13	13	14	14	13
i.	8	7	9	8	8	8	9	7	8
Scales K.	10	10	10	10	10	10	10	10	10
Scales L.	52	51	51	52	53	53	53	52	53
Scales D.	6	5	6	5	5	6	6	5	5
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	18 18	18 18	19 19	18 18	17 16	18 16	18 18	17 17	17 17
Pl. Fin	9 9	8 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	17	18	17	17	18	19	18	18	19
A. Fin	16	17	16	15	16	17	15	16	15
Total V.	52	52	52	-	-	52	53	53	52
A. V.	22	25	22	-	-	23	24	25	23
C. V.	30	27	30	-	-	29	29	28	29
G. Ra.	67	63	64	61	65	64	65	64	66
Br.	8 8	9 9	7 8	8 8	8 8	8 8	8 8	8 8	8 8

175	196	191	165	161	190	188	181	195	180	171
♀	♂	♂	♂	♀	♂	♀	♀	♂	♀	♀
7	5	-	-	-	6	5	6	5	5	5
97	87	75	92	89	85	88	92	77	95	95
201	194	197	204	200	200	198	202	185	200	205
47	47	47	49	47	48	47	47	45	48	48
23	21	21	22	22	22	22	22	21	22	23
13	12	12	13	13	12	13	12	12	12	13
21	20	20	21	20	21	20	20	19	20	21
12	13	12	12	12	12	13	12	12	13	13
8	8	7	8	7	8	7	7	7	8	8
11	9	10	10	10	9	11	10	10	10	10
54	52	55	52	54	52	55	53	52	53	53
6	6	6	6	5	5	5	6	5	6	6
6	6	6	6	7	6	6	6	6	6	6
19 19	17 17	17 17	17 17	17 17	18 18	18 18	18 17	18 17	19 18	17 18
9 9	9 9	9 9	9 9	8 8	9 9	9 8	9 9	9 8	9 9	9 9
19	18	16	17	18	19	18	17	19	17	18
17	16	15	16	16	16	16	15	17	14	16
51	51	52	52	52	51	-	-	51	52	53
23	24	24	23	23	22	-	-	22	24	23
28	27	28	29	29	29	-	-	29	28	30
67	66	64	64	62	66	63	61	62	64	63
9 8	8 8	8 8	8 8	8 8	8 7	8 8	9 8	8 7	8 8	9 9

WALKER ROCK

Number	168	170	156	163	164	162	189	184	144
Sex	♂	♀	♂	♂	♂	♂	♀	♀	♂
Age	-	-	4	-	6	-	6	2	6
Wt.	137	61	86	84	84	61	86	55	100
F. L.	221	177	192	200	200	174	198	169	208
H. L.	51	41	46	48	46	41	46	41	51
u. j.	24	20	22	22	22	18	21	19	23
m.	14	11	12	13	13	11	12	11	14
p. o.	22	17	20	21	20	17	19	17	22
e. d.	14	11	12	13	12	11	12	11	13
i.	8	7	7	8	7	7	7	6	8
Scales K.	11	10	9	11	10	12	10	11	10
Scales L.	54	49	51	52	53	54	53	51	52
Scales D.	5	5	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	18 18	17 17	17 16	18 18	17 18	17 17	18 17	17 18	18 18
Pl. Fin	9 9	9 8	9 9	8 9	9 9	9 7	9 9	9 9	9 9
D. Fin	18	18	18	18	18	17	18	18	19
A. Fin	17	15	16	15	16	16	16	16	16
Total V.	52	52	52	52	52	51	52	52	52
A. V.	23	23	23	24	24	22	24	23	24
C. V.	29	29	29	28	28	29	28	29	28
G. Ra.	65	67	62	64	65	66	65	65	65
Br.	8 9	8 8	8 8	8 8	8 7	8 8	8 8	8 8	8 9

150	197	145	194	141	137	143	142	167	155	185
♀	♂	♂	♂	♂	♀	♀	♂	♂	♂	♀
6	2	-	-	6	6	-	6	2	5	-
90	53	83	86	101	94	83	84	53	84	83
199	172	195	200	207	204	202	204	165	200	200
47	43	47	49	48	50	48	48	40	42	47
22	19	22	23	23	24	22	22	18	21	22
13	11	13	13	13	14	12	13	10	12	12
20	17	20	20	21	21	20	21	17	20	19
13	12	12	13	13	13	12	13	11	12	13
7	6	7	8	8	8	7	8	6	7	8
10	9	10	10	10	10	10	10	10	11	10
52	53	51	51	52	53	51	51	50	53	50
6	6	5	6	6	6	5	6	6	6	6
6	6	6	6	6	6	6	6	6	6	5
17 17	18 18	18 17	18 18	18 18	17 17	19 18	17 17	19 19	17 18	17 17
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
17	16	18	17	18	17	18	18	18	17	19
16	16	16	16	15	17	16	15	16	17	16
52	-	51	52	51	52	51	52	51	53	-
24	-	23	24	23	25	24	23	22	24	-
28	-	28	28	28	27	27	29	29	29	-
62	61	64	70	67	68	67	65	64	63	64
8 8	8 8	8 8	9 9	8 8	8 8	8 8	8 8	8 9	8 8	8 8

WALKER ROCK

Number	186	149	166	153	136	158	173	154	138
Sex	♀	♀	♀	♀	♀	♂	♀	♂	♀
Age	4	-	-	6	5	7	5	4	5
Wt.	78	90	87	97	72	86	59	76	95
F. L.	185	203	198	210	185	198	176	191	209
H. L.	44	48	47	48	45	46	43	45	50
u. j.	21	22	23	23	21	21	20	22	23
m.	12	13	13	12	12	12	11	12	13
p. o.	19	20	20	21	20	20	18	19	22
e. d.	12	13	12	12	12	12	12	13	12
i.	7	8	7	7	7	7	7	7	8
Scales K.	10	10	10	10	10	10	10	10	11
Scales L.	50	54	52	53	50	53	52	51	52
Scales D.	5	6	6	6	6	6	6	6	6
Scales V.	5	6	6	6	6	6	6	6	6
Pt. Fin	18 18	17 17	18 18	18 18	17 17	18 18	18 18	18 18	19 18
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	18	19	17	18	18	17	18	18	18
A. Fin	-	18	15	16	16	16	14	18	15
Total V.	-	53	-	52	-	51	-	-	52
A. V.	-	23	-	24	-	23	-	-	23
C. V.	-	30	-	28	-	28	-	-	29
G. Ra.	63	63	61	62	61	65	61	64	62
Br.	8 8	8 8	8 8	8 8	8 8	8 8	8 8	9 8	8 8

159	140	131	182	151	169	122	148	124	134	174
♂	♂	♂	♀	♀	♀	♂	♀	♂	♀	♂
5	-	-	7	-	2	-	5	6	6	-
69	110	78	77	84	47	91	105	93	112	93
188	210	195	191	196	163	200	210	207	217	212
45	48	46	46	47	40	48	50	47	51	50
21	24	21	22	22	19	22	24	22	23	24
12	12	12	12	12	11	13	14	12	13	14
20	21	20	19	20	17	21	20	19	23	22
12	13	12	12	12	11	13	13	12	14	12
6	8	7	8	7	6	8	8	7	8	8
10	11	10	10	10	10	10	10	12	11	10
52	52	54	53	53	52	53	52	54	53	52
6	6	6	6	6	6	6	5	6	6	6
6	6	6	6	6	6	6	6	6	6	6
17 17	18 17	17 16	18 18	18 18	18 18	17 17	17 17	17 18	18 18	17 18
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
18	18	18	17	18	18	17	18	18	18	18
17	15	15	15	17	15	15	16	15	16	16
51	52	53	-	-	52	-	52	-	52	52
23	23	23	-	-	24	-	22	-	23	23
28	29	30	-	-	28	-	30	-	29	29
62	62	63	66	65	62	66	61	63	63	65
8 8	8 8	8 8	7 8	8 8	8 8	8 8	8 8	8 8	7 8	8 7

WALKER ROCK

Number	129	147	123	135	152	133	121	98	132
Sex	♀	♂	♀	♀	♀	♀	♂	♂	♂
Age	5	-	6	6	3	6	5	-	-
Wt.	78	67	91	91	66	89	66	85	57
F. L.	191	182	209	207	174	201	175	200	167
H. L.	47	44	50	49	42	49	41	47	40
u. j.	23	21	24	22	20	23	19	23	19
m.	13	12	12	13	11	13	11	13	11
p. o.	20	19	22	20	17	21	17	20	16
e. d.	12	12	12	12	12	12	10	13	11
i.	7	7	8	8	6	8	6	8	6
Scales K.	10	10	11	11	11	10	11	9	10
Scales L.	52	51	53	52	52	50	53	52	51
Scales D.	6	6	6	6	6	6	5	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	16 16	17 17	17 17	17 17	17 17	18 18	18 18	17 17	18 19
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	18	17	17	17	19	17	18	19	17
A. Fin	17	15	15	15	16	16	16	17	16
Total V.	-	-	52	-	52	51	-	-	52
A. V.	-	-	23	-	26	22	-	-	23
C. V.	-	-	29	-	26	29	-	-	29
G. Ra.	64	62	64	68	61	65	66	63	64
Br.	7 8	9 9	8 8	8 8	8 8	8 8	9 9	8 8	9 8

128	120	93	114	108	125	157	105	119	139	126
♂	♂	♀	♂	♀	♂	♀	♀	♂	♂	♂
6	6	5	-	5	6	2	-	-	4	5
70	80	94	54	92	79	60	91	51	64	89
189	204	207	174	199	191	179	203	173	183	202
47	49	49	41	45	46	43	49	42	45	48
23	22	22	20	22	22	19	23	19	20	22
13	13	13	11	12	12	11	13	11	11	12
20	21	21	17	20	18	17	21	18	19	20
13	13	12	12	13	12	12	12	11	11	12
7	8	8	7	8	8	7	8	7	7	7
10	10	10	10	12	10	10	10	9	10	10
52	53	52	52	56	51	49	55	51	51	52
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
16 17	17 18	17 18	18 18	17 17	18 18	17 18	17 17	18 18	18 17	18 17
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
18	19	18	18	18	18	19	18	19	17	18
17	14	16	15	17	17	17	17	16	16	16
52	-	53	-	-	-	-	-	51	51	-
23	-	24	-	-	-	-	-	22	23	-
29	-	29	-	-	-	-	-	29	28	-
66	67	68	62	62	62	65	66	63	62	63
8 8	8 8	8 8	8 8	8 9	8 8	8 8	8 8	8 8	8 8	8 8

WALKER ROCK

Number	130	89	127	146	99	103	100	86	110
Sex	♀	♂	♂	♀	♂	♀	♀	♂	♀
Age	2	6	6	-	3	-	-	6	-
Wt.	67	98	83	46	57	42	103	75	84
F. L.	175	208	195	165	176	159	210	192	203
H. L.	41	50	47	39	42	38	48	45	48
u. j.	19	23	22	18	20	18	23	22	23
m.	11	13	12	11	12	10	13	12	13
p. o.	17	22	20	16	17	16	21	18	20
e. d.	12	13	12	10	11	10	13	12	13
i.	7	8	8	6	6	5.5	8	7	8
Scales K.	9	10	10	10	12	11	11	10	10
Scales L.	53	53	56	51	52	53	53	51	53
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	5	6
Pt. Fin	18 18	- 17	19 18	18 17	19 20	19 19	18 18	18 17	18 17
Pl. Fin	9 9	9 9	9 8	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	19	19	19	19	18	17	19	19	17
A. Fin	16	17	17	16	16	15	17	16	16
Total V.	-	52	52	52	51	52	-	52	-
A. V.	-	24	23	23	24	23	-	23	-
C. V.	-	28	29	29	27	29	-	29	-
G. Ra.	-	64	62	60	64	67	63	62	64
Br.	8 8	8 8	8 8	8 8	9 8	8 8	8 8	8 8	8 7

107	87	97	90	117	88	160	80	96	112	94
♀	♀	♂	♂	♀	♂	♀	♀	♂	♂	♀
-	-	-	-	-	5	-	-	-	-	5
84	84	98	74	78	92	98	80	78	82	96
200	207	208	190	196	205	202	197	195	201	208
48	50	48	43	47	48	49	47	48	47	48
22	23	23	21	22	22	23	22	22	22	22
12	13	13	12	12	13	14	12	13	13	13
20	21	21	17	20	21	21	21	20	20	20
12	12	12	12	13	12	12	12	12	13	13
8	8	8	7	8	8	8	8	7	7	8
11	10	11	10	10	11	9	10	10	10	10
51	52	52	51	54	54	53	51	51	52	53
6	6	5	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
18 18	18 18	18 18	18 18	18 17	18 18	19 19	17 17	17 18	18 19	17 17
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
17	17	18	18	19	19	18	17	18	18	19
15	15	16	17	16	15	16	16	17	16	16
-	-	51	51	54	53	-	53	51	52	52
-	-	24	22	24	23	-	24	21	22	24
-	-	27	29	30	30	-	29	30	30	28
62	64	67	64	61	66	67	65	64	62	62
8 8	8 8	8 8	8 8	8 8	9 9	8 8	9 8	8 8	8 8	8 8

WALKER ROCK

Number	64	65	91	84	71	109	101	116	92
Sex	♀	♂	♂	♀	♀	♂	♀	♂	♂
Age	-	-	-	5	4	-	-	-	-
Wt.	88	81	84	97	81	57	88	72	60
F. L.	197	202	202	211	198	174	201	186	179
H. L.	47	49	48	48	46	42	48	45	42
u. j.	22	22	21	24	22	19	23	22	20
m.	13	13	13	13	12	11	13	12	11
p. o.	20	21	21	21	20	16	20	19	18
e. d.	12	13	12	13	13	12	13	12	11
i.	7	8	8	8	8	6.5	8	7	6
Scales K.	10	12	12	11	10	10	10	9	10
Scales L.	51	52	53	53	50	55	55	54	50
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	16 17	18 18	18 18	17 17	20 20	18 18	18 18	18 18	18 18
Pl. Fin	9 8	9 9	10 9	9 8	9 9	9 9	9 9	9 9	9 9
D. Fin	19	18	18	18	18	18	17	17	18
A. Fin	14	16	16	16	16	16	16	16	16
Total V.	52	52	53	52	-	-	52	53	51
A. V.	23	25	24	23	-	-	24	24	23
C. V.	29	27	29	29	-	-	28	29	28
G. Ra.	67	62	60	65	63	65	63	66	63
Br.	8 8	8 8	8 8	8 8	8 8	8 8	8 8	8 8	8 8

81	82	74	76	30	72	85	75	78	118	68
♂	♀	♂	♂	♀	♂	♂	♂	♀	♀	♀
-	-	2	-	4	6	6	-	-	-	6
76	90	48	106	99	72	80	91	148	65	90
190	195	170	210	209	196	200	206	228	184	199
47	47	42	49	48	47	48	48	50	44	48
22	23	20	22	23	22	22	22	23	21	22
12	13	12	12	13	12	13	13	13	12	13
19	20	17	19	22	20	21	21	22	18	21
12	13	11	13	12	12	12	12	13	12	13
7	8	6	8	8	7	7	7	9	7	8
10	11	10	10	10	10	10	11	10	9	11
53	51	51	50	50	53	54	55	53	54	50
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
18 17	17 17	18 18	18 17	19 19	17 17	18 18	17 17	17 17	19 19	18 18
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	8 8
19	18	18	18	19	19	19	19	16	17	18
16	16	16	16	16	16	16	16	14	17	15
-	51	50	52	52	53	52	-	51	52	52
-	23	23	22	23	23	23	-	23	24	23
-	28	27	30	29	30	29	-	28	28	29
61	62	62	-	65	64	64	62	65	65	65
9 8	8 8	8 9	8 8	9 9	8 8	8 8	8 8	8 7	9 9	8 8

WALKER ROCK

Number	104	52	61	47	67	51	62	73	38
Sex	♀	♂	♂	♀	♂	♂	♀	♀	♀
Age	5	-	4	5	-	-	5	-	3
Wt.	106	89	76	99	96	133	83	88	76
F. L.	207	202	191	213	208	217	199	203	194
H. L.	48	47	46	51	48	50	48	48	47
u. j.	22	22	22	24	23	24	23	24	22
m.	13	13	12	14	13	14	13	13	12
p. o.	21	22	20	23	21	22	20	20	20
e. d.	13	12	12	13	12	13	12	12	12
i.	8	8	7	8	8	8	8	8	7
Scales K.	12	11	10	11	10	10	11	10	10
Scales L.	53	53	52	51	53	54	51	53	55
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	18 18	18 18	19 18	17 17	17 18	17 17	17 18	17 17	19 19
Pl. Fin	9 9	9 9	9 7	9 9	9 9	9 9	9 9	8 9	9 9
D. Fin	18	18	18	17	18	18	17	18	18
A. Fin	15	17	16	16	16	15	16	15	17
Total V.	53	-	51	51	-	52	51	52	-
A. V.	25	-	22	23	-	24	22	22	-
C. V.	28	-	29	28	-	28	29	30	-
G. Ra.	67	64	63	65	59	65	63	63	68
Br.	8 8	8 8	8 8	9 8	8 8	8 8	8 8	9 8	8 9

45	83	32	56	66	60	37	50	39	53	59
♂	♀	♂	♂	♀	♀	♂	♂	♂	♀	♂
3	6	-	5	5	6	4	4	-	4	-
81	108	95	100	81	83	75	84	57	82	121
191	204	199	205	200	199	188	196	179	195	220
46	47	48	49	46	48	46	46	43	47	50
22	23	22	23	23	22	22	22	20	22	24
12	13	12	13	13	13	13	12	11	12	13
19	20	20	21	20	20	19	20	17	20	22
12	12	12	13	12	12	12	12	11	11	13
7	8	7	8	8	7	7	8	7	7	9
10	10	10	10	10	9	9	10	10	10	10
53	50	52	52	53	55	54	51	53	53	53
7	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
19 19	18 18	17 17	18 18	18 17	17 17	18 18	18 18	18 18	17 17	17 16
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
19	17	19	17	17	18	19	17	17	18	18
17	16	15	17	15	16	16	16	15	14	16
53	52	51	52	52	52	52	52	52	50	51
24	24	23	23	23	22	22	23	23	21	23
29	28	28	29	29	30	30	29	29	29	28
63	68	67	67	64	62	67	63	62	62	64
8 8	8 8	9 8	8 8	9 9	8 8	8 8	8 8	8 8	8 8	8 8

WALKER ROCK

Number	15	70	43	33	44	106	115	46	102
Sex	♂	♂	♂	♂	♂	♀	♂	♂	♀
Age	4	-	3	4	4	4	6	4	-
Wt.	99	80	75	90	92	73	77	92	90
F. L.	201	192	182	207	209	183	191	201	201
H. L.	50	47	43	50	49	42	47	47	47
u. j.	22	23	21	22	23	20	22	23	23
m.	13	12	12	13	14	12	13	13	13
p. o.	22	20	19	22	21	18	19	20	20
e. d.	12	11	10	13	13	12	12	12	12
i.	8	7	7	8	8	7	8	8	8
Scales K.	11	10	11	10	11	10	10	10	10
Scales L.	52	54	52	54	53	53	52	51	54
Scales D.	6	6	6	6	5	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	16 16	18 18	17 17	19 19	17 17	18 18	17 17	17 18	18 18
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	18	18	18	18	17	18	17	18	18
A. Fin	15	17	16	16	16	16	15	18	16
Total V.	51	51	51	52	53	51	50	-	52
A. V.	23	24	22	22	22	23	-	-	25
C. V.	28	27	29	30	31	28	-	-	27
G. Ra.	63	65	69	63	66	64	61	63	65
Br.	8 8	8 8	8 8	8 8	8 8	8 8	8 8	8 8	8 8

23	26	77	69	58	113	27	35	57	16	49
♂	♂	♀	♂	♂	♀	♂	♀	♂	♂	♀
-	2	5	6	-	-	2	3	5	4	4
84	52	97	80	90	52	51	77	90	67	85
193	167	204	201	200	170	167	197	200	185	204
45	40	48	49	47	41	41	48	49	44	49
21	19	23	22	22	20	19	23	22	20	23
13	10	13	13	12	11	11	13	13	12	13
19	17	21	21	20	17	17	21	21	18	22
12	11	13	12	12	11	11	12	12	11	12
7	6	8	8	7	7	6	7	8	7	8
10	10	10	10	11	10	10	10	10	12	11
55	53	56	57	54	52	52	53	52	53	51
5	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
18 18	17 17	19 19	17 17	18 17	18 17	18 19	17 17	18 18	17 17	18 18
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	8 8
17	19	18	17	18	18	18	18	17	20	20
15	16	16	16	17	16	15	16	16	16	15
53	52	51	-	-	52	50	53	51	52	51
24	24	21	-	-	22	22	23	22	23	25
29	28	30	-	-	30	28	30	29	29	26
62	63	65	64	62	62	64	66	65	62	65
8 8	8 8	9 9	8 7	8 7	8 8	8 8	8 8	9 9	8 8	9 8

WALKER ROCK

Number	28	18	54	40	42	111	22	48	12
Sex	♀	♀	♂	♀	♂	♂	♀	♂	♂
Age	3	3	4	4	3	6	-	3	4
Wt.	89	83	63	94	72	66	82	88	81
F. L.	203	199	185	202	192	183	197	200	190
H. L.	48	46	44	46	45	44	48	48	46
u. j.	23	22	21	22	21	21	22	23	22
m.	13	12	12	12	12	12	13	13	13
p. o.	21	20	18	19	19	18	21	21	19
e. d.	12	12	11	12	12	12	12	12	12
i.	7.5	7	7	7	7	7	8	8	7
Scales K.	11	11	10	12	10	12	10	10	10
Scales L.	53	56	53	53	54	56	54	54	55
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	7	6	6	7	6
Pt. Fin	18 18	18 18	18 17	18 18	17 17	17 17	18 17	18 18	18 18
Pl. Fin	9 9	9 9	9 9	8 8	9 9	9 8	9 9	9 9	9 9
D. Fin	18	19	18	18	18	17	17	18	18
A. Fin	16	16	16	16	15	16	16	17	16
Total V.	52	52	52	53	52	52	52	50	53
A. V.	23	23	23	25	23	24	23	23	23
C. V.	29	29	29	28	29	28	29	27	30
G. Ra.	66	68	66	63	68	63	67	63	66
Br.	8 8	9 8	8 8	8 8	8 8	8 7	9 8	8 8	8 8

17	19	9	6	10	7	34	31	20	29	5
♂	♀	♂	♂	♂	♀	♂	♂	♂	♂	♀
3	-	3	-	3	-	4	5	-	5	-
80	83	94	116	78	96	85	78	88	96	95
186	195	203	216	194	203	203	190	200	207	205
44	45	48	49	45	48	48	47	47	48	48
21	22	22	23	21	24	22	22	21	23	23
12	13	13	14	13	13	13	13	12	13	13
18	18	20	21	19	20	21	20	20	20	20
12	12	13	12	12	13	12	12	12	13	12
7	7	8	8	7.5	8	8	7	7	8	8
10	10	11	11	10	12	10	11	10	11	11
51	51	53	55	52	51	54	51	52	54	53
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
17 18	17 17	17 17	18 18	16 16	18 18	17 17	18 18	18 18	18 18	18 17
9 9	9 9	9 9	9 9	9 8	9 9	9 8	9 9	9 9	9 8	9 9
19	18	18	18	19	17	17	18	18	18	19
16	18	17	15	17	16	17	16	17	15	17
51	52	52	52	52	52	52	51	52	52	52
23	23	22	24	23	23	23	22	23	25	25
28	29	30	28	29	29	29	29	29	27	27
65	63	66	67	63	64	62	69	61	65	66
8 8	8 8	8 8	8 8	8 8	8 8	9 9	9 8	8 8	8 8	7 7

WALKER ROCK

Number	41	14	79	11	2	13	3	25	63
Sex	♀	♀	♀	♀	♀	♂	♂	♂	♂
Age	4	-	-	4	4	4	-	3	4
Wt.	89	95	88	95	100	81	94	82	84
F. L.	201	205	203	203	212	202	205	200	191
H. L.	48	50	49	48	49	48	48	48	45
u. j.	23	23	23	23	23	22	22	23	22
m.	13	13	13	13	13	13	13	13	12
p. o.	22	22	22	21	22	20	21	20	19
e. d.	12	13	13	13	12	12	12	12	11
i.	8	8	8	8	8	8	8	8	8
Scales K.	10	10	10	10	12	10	10	11	10
Scales L.	54	53	54	52	52	54	53	52	54
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	18 17	18 18	17 17	17 16	18 17	17 17	17 17	17 17	17 17
Pl. Fin	9 9	9 9	9 9	8 9	9 9	9 9	9 9	9 9	9 9
D. Fin	19	17	19	19	18	19	18	18	19
A. Fin	15	17	16	17	16	16	17	15	15
Total V.	52	52	53	53	52	52	51	-	-
A. V.	23	23	23	23	24	24	24	-	-
C. V.	29	29	30	30	28	28	27	-	-
G. Ra.	66	63	66	63	64	62	65	66	64
Br.	8 8	8 8	7 8	8 8	8 7	8 8	7 7	8 8	8 8

1	8	55	36	4	21	95	24
♂	♂	♀	♀	♀	♀	♂	♂
-	4	5	4	-	3	5	-
94	85	97	90	77	73	67	45
209	202	210	200	191	190	180	158
48	47	50	47	45	44	44	39
22	22	23	22	21	20	21	18
13	13	13	13	12	12	12	11
20	20	22	21	19	18	18	16
12	12	13	12.5	11	11	11.5	11
8	7	8	7	7	7	7	6
10	11	10	9	11	10	10	10
53	54	53	52	53	53	51	52
6	6	6	6	6	6	6	6
6	7	6	6	6	6	6	6
18 18	18 18	17 18	19 19	18 18	18 18	17 17	18 18
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
18	18	19	19	19	18	19	19
16	16	16	17	18	17	16	15
52	52	51	52	52	51	52	52
23	23	22	24	24	23	23	22
29	29	29	28	28	28	29	30
67	65	62	65	65	65	69	62
7 7	9 9	8 8	8 8	8 8	8 7	8 8	8 8

TUK

Number	974	1009	999	880	718	919	923	954	926
Sex	♂	♂	♀	♀	♀	♀	♀	♀	♀
Age	9	-	5	4	10	-	11	11	-
Wt.	275	420	112	75	415	460	400	400	455
F. L.	264	302	215	190	313	322	300	294	320
H. L.	55	65	47	40	64	65	73	63	65
u. j.	25	28	21	19	30	30	29	29	30
m.	15	17	12	11	18	18	17	17	18
p. o.	26	30	22	17	30	30	30	28	30
e. d.	13	15	10	10	14	15	15	15	15
i.	10	11	8	6	12	12	11	10	10
Scales K.	11	11	11	12	12	12	12	12	11
Scales L.	55	56	51	57	56	57	55	54	53
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	7	6	6	6	6	6	5
Pt. Fin	17 16	16 16	18 18	17 17	- -	17 16	- -	16 16	17 17
Pl. Fin	10 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	17	18	18	18	18	17	17	17	18
A. Fin	14	17	14	13	14	15	14	17	17
Total V.	52	53	53	53	55	54	53	53	53
A. V.	24	24	23	24	25	25	25	24	25
C. V.	28	29	30	29	30	29	28	29	28
G. Ra.	67	70	69	59	71	67	63	67	65
Br.	6 -	7 7	8 8	- -	8 8	7 8	8 7	6 7	7 7

915	973	921	990	913	978	976	967	911	987	948
♀	♀	♂	♀	♂	♀	♀	♀	♀	♀	♂
11	9	-	9	-	9	12	-	10	-	9
430	350	430	325	455	360	410	480	380	450	320
315	305	308	285	317	298	311	332	297	314	278
65	65	64	59	66	62	66	69	63	66	59
29	29	29	27	30	30	30	31	28	31	26
18	17	18	16	17	17	18	19	17	18	15
31	30	30	27	32	29	31	33	30	32	27
15	14	15	14	14	15	15	16	14	15	14
11	11	12	10	11	11	11	11	11	11	10
12	11	11	10	12	12	11	10	11	11	10
55	56	54	56	55	54	52	57	56	54	53
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
16 16	17 17	17 17	17 17	16 16	16 16	17 17	16 16	17 17	17 16	18 17
9 9	9 9	9 9	9 9	9 9	9 9	9 8	8 9	9 9	9 9	9 10
19	19	19	17	18	18	18	18	19	18	18
16	16	15	16	16	17	17	17	17	17	17
54	54	53	53	53	52	54	53	54	54	52
25	24	24	25	25	23	25	24	26	26	25
29	30	29	28	28	29	29	29	28	28	27
67	66	72	63	67	68	65	70	68	65	66
8 8	9 7	8 8	8 7	8 7	8 8	8 8	8 7	8 8	8 7	8 8

TUK

Number	986	891	992	920	955	914	960	802	747
Sex	♂	♀	♂	♀	♀	♂	♀	♀	♀
Age	9	11	9	13	-	-	-	-	12
Wt.	375	405	390	475	460	460	425	490	425
F. L.	290	309	308	318	311	317	310	309	308
H. L.	59	62	64	68	68	65	66	65	64
u. j.	28	28	29	32	30	29	30	30	30
m.	16	16	18	18	18	17	17	17	17
p. o.	28	29	30	33	31	31	32	30	30
e. d.	14	15	15	16	15	15	15	14	14
i.	11	10	11	11	11	10	11	12	11
Scales K.	12	12	11	11	11	11	11	11	11
Scales L.	55	53	55	53	53	55	54	54	56
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	15 16	16 16	17 17	17 16	16 16	16 16	16 16	16 16	16 16
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	18	18	18	19	19	17	17	17	17
A. Fin	14	15	16	14	15	16	16	17	18
Total V.	54	52	52	52	53	53	53	52	53
A. V.	25	24	25	24	24	24	24	25	24
C. V.	29	28	27	28	29	29	29	27	29
G. Ra.	69	65	68	67	65	68	66	70	68
Br.	8 7	7 7	7 8	9 6	8 8	8 8	8 7	7 7	9 8

728	979	1004	748	941	820	742	628	928	998	833
♀	♂	♂	♀	♀	♀	♂	♂	♀	♀	♀
-	-	11	12	-	8	11	13	-	9	-
425	365	445	425	325	275	450	470	375	425	325
304	294	316	307	272	274	307	313	303	315	303
64	63	65	64	60	58	64	64	63	65	63
29	29	30	29	27	26	30	30	30	31	30
16	16	17	17	17	16	18	18	17	19	17
30	30	31	31	27	26	29	31	30	31	30
14	14	15	14	13	13	15	14	15	16	14
12	11	10	12	10	10	12	11	11	11	12
11	12	12	11	11	11	11	11	12	11	11
55	52	57	52	54	52	52	52	52	55	53
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
16 16	17 17	17 17	16 16	17 17	16 16	17 17	17 17	16 16	16 15	16 16
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
17	17	18	18	17	16	17	15	17	17	18
15	16	15	16	15	16	16	15	15	16	15
53	53	55	52	53	52	53	53	54	54	52
24	24	26	23	24	24	24	24	27	25	24
29	29	29	29	29	28	29	29	27	29	28
66	67	68	66	62	71	69	61	72	69	68
8 8	9 8	8 8	8 8	8 8	9 8	8 8	8 8	8 8	7 7	8 8

TUK

Number	983	829	823	860	927	732	647	840	950
Sex	♂	♀	♀	♀	♂	♀	♀	♀	♂
Age	8	12	-	11	-	13	-	14	8
Wt.	320	410	500	425	450	505	475	510	310
F. L.	276	312	335	315	310	325	320	325	266
H. L.	57	64	67	66	65	65	68	70	55
u. j.	26	29	30	29	30	30	31	31	26
m.	15	17	18	19	17	18	18	18	15
p. o.	26	30	33	31	31	32	33	34	26
e. d.	13	14	15	15	15	14	15	15	13
i.	9	12	13	13	11	13	12	13	9
Scales K.	11	11	12	10	11	11	11	11	11
Scales L.	57	55	56	54	58	58	54	56	55
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	17 17	17 17	17 16	17 17	17 16	17 16	17 17	17 17	16 15
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	17	18	18	18	17	18	18	18	19
A. Fin	15	16	15	17	15	16	17	17	17
Total V.	54	53	54	53	54	54	53	53	54
A. V.	25	27	26	24	26	25	26	24	24
C. V.	29	26	28	29	28	29	27	29	30
G. Ra.	63	63	67	67	67	70	70	63	68
Br.	8 8	7 8	8 7	8 8	7 7	8 7	8 8	8 8	8 8

898	800	905	810	818	720	834	831	730	678	922
♀	♂	♀	♀	♀	♂	♂	♀	♀	♂	♀
-	-	-	9	8	-	-	12	-	-	7
275	410	500	375	270	350	375	425	425	370	230
275	306	321	299	261	296	298	324	320	305	265
57	67	66	64	56	65	63	67	65	66	55
26	30	29	29	25	29	28	30	30	30	25
16	18	18	18	15	18	16	17	16	17	15
26	31	-	30	25	31	31	32	29	32	26
12	15	15	15	13	14	15	15	14	15	14
10	11	12	12	10	11	10	11	12	12	9
11	11	11	11	12	12	11	11	12	11	11
54	54	54	52	52	53	55	54	55	58	54
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
- 16	16 16	17 17	16 16	17 17	17 17	17 17	16 16	18 17	16 16	17 17
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
17	18	17	18	18	19	18	17	18	18	18
16	16	16	16	17	16	15	15	15	16	16
52	-	55	52	54	53	55	52	53	54	53
24	-	26	24	26	24	25	23	24	25	24
28	-	29	28	28	29	30	29	29	29	29
68	62	66	64	67	70	68	67	64	66	68
8 8	8 8	7 8	8 7	7 7	8 7	8 8	8 9	8 8	8 8	7 7

TUK

Number	692	660	957	939	975	749	864	858	835
Sex	♀	♀	♂	♂	♂	♂	♀	♀	♀
Age	10	9	7	10	7	-	-	12	-
Wt.	455	450	275	400	290	405	425	400	525
F. L.	324	315	259	295	268	298	305	313	323
H. L.	67	68	56	61	57	62	63	65	67
u. j.	31	31	25	28	24	27	29	30	32
m.	18	17	14	16	16	16	18	18	18
p. o.	31	33	26	28	27	28	30	31	32
e. d.	15	15	14	14	13	14	15	14	15
i.	11	12	9	10	10	11	12	12	13
Scales K.	12	10	11	11	11	11	11	11	10
Scales L.	54	53	53	54	55	59	55	54	53
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	17 17	17 17	17 17	17 17	17 17	17 17	16 16	17 17	17 17
Pl. Fin	9 9	9 8	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	16	18	18	18	18	17	17	18	18
A. Fin	17	16	17	17	15	17	15	15	17
Total V.	55	53	51	53	53	53	53	54	53
A. V.	26	23	22	24	25	25	24	25	24
C. V.	29	30	29	29	28	28	29	29	29
G. Ra.	65	66	67	61	65	64	70	68	70
Br.	8 8	8 8	7 8	7 7	7 8	8 8	7 8	8 8	7 8

807	809	859	844	837	812	801	896	972	902	946
♂	♀	♀	♀	♀	♀	♂	♀	♀	♂	♀
12	12	9	12	-	10	13	-	-	11	6
425	410	350	425	450	400	480	475	560	420	250
308	313	303	310	315	316	321	320	332	309	261
67	65	62	67	66	64	66	65	68	66	56
30	29	28	30	30	30	30	29	31	30	26
18	17	16	17	18	18	18	18	18	18	15
31	31	30	30	30	30	32	30	34	31	27
14	14	13	14	15	15	14	14	16	14	13
12	11	10	12	12	12	12	12	12	13	9
11	11	11	10	11	11	11	11	11	11	10
51	55	55	51	52	54	54	52	55	53	54
6	6	6	6	6	5	6	6	6	6	6
6	6	6	6	6	6	6	5	6	6	6
16 17	17 17	16 16	16 16	18 17	17 17	18 18	17 17	16 16	17 17	17 17
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
18	18	18	17	19	17	18	17	18	18	17
15	16	14	17	18	16	16	16	15	16	17
54	54	52	53	53	54	53	53	54	53	53
24	25	24	25	24	25	25	25	26	24	24
30	29	28	28	29	29	28	28	28	29	29
66	63	66	70	71	67	69	69	65	64	67
9 9	8 7	7 7	7 7	8 8	8 9	7 8	8 7	8 8	7 8	8 8

TUK

Number	870	916	953	930	962	824	996	937	821
Sex	♂	♀	♀	♀	♀	♀	♀	♂	♂
Age	8	14	-	5	4	4	-	5	4
Wt.	340	525	455	110	98	99	120	98	80
F. L.	277	316	318	205	197	202	212	193	193
H. L.	61	62	69	45	43	43	45	42	42
u. j.	27	31	30	21	19	20	20	20	20
m.	16	18	18	12	11	12	12	11	11
p. o.	29	32	33	21	20	19	19	18	18
e. d.	14	15	16	11	10	10	11	10	10
i.	9	11	11	7	6	7	7	6	6
Scales K.	10	10	11	11	10	11	11	10	11
Scales L.	53	54	56	54	55	52	53	52	54
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	5	6	6	6
Pt. Fin	17 17	16 16	16 16	17 17	17 17	17 17	17 17	17 16	16 16
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	18	16	17	18	19	18	18	18	18
A. Fin	16	14	16	15	15	16	14	12	15
Total V.	-	52	54	54	52	53	53	53	52
A. V.	-	24	25	25	24	24	23	24	24
C. V.	-	28	29	29	28	29	30	29	28
G. Ra.	69	71	67	67	70	65	67	64	69
Br.	8 9	8 8	7 7	8 8	7 7	7 8	7 7	8 8	8 7

951	900	819	664	969	881	977	814	931	893	961
♂	♀	♀	♀	♂	♀	♀	♂	♀	♀	♂
4	4	3	4	4	5	-	4	4	4	5
75	84	68	87	82	111	84	95	102	88	98
198	193	186	195	194	203	189	195	200	197	194
41	43	41	42	43	45	43	41	45	42	41
20	20	19	20	19	21	20	20	20	20	19
10	11	11	11	12	12	11	11	12	11	10
18	19	19	19	20	20	19	18	20	18	19
10	10	10	10	11	11	10	10	11	11	10
7	7	6	7	7	8	7	7	7	6	6
11	11	11	11	11	12	11	10	10	10	10
53	52	55	52	53	53	53	53	51	56	54
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
18 17	17 17	17 16	17 17	17 17	17 17	17 17	17 17	16 17	17 17	19 18
9 9	99	8 9	9 9	9 9	9 9	9 9	9 9	9 9	9 10	9 9
18	18	18	18	18	18	19	19	18	18	19
15	16	18	15	14	18	16	15	16	17	17
53	53	54	53	52	53	53	53	53	54	54
25	24	24	25	24	25	25	24	24	25	24
28	29	30	28	28	28	28	29	29	29	30
64	64	63	65	66	65	68	68	65	67	69
7 7	8 7	8 8	8 8	7 7	8 8	8 8	8 8	8 8	8 8	8 8

TUK

Number	883	811	875	934	852	659	813	899	630
Sex	♀	♂	♀	♀	♀	♀	♀	♂	♀
Age	4	4	4	4	4	4	4	4	4
Wt.	91	95	82	92	83	81	80	101	88
F. L.	194	193	193	198	187	195	197	195	195
H. L.	43	43	45	44	42	42	41	43	42
u. j.	20	19	20	20	19	19	19	19	19
m.	11	11	12	11	11	11	11	11	11
p. o.	19	20	21	21	20	19	18	19	20
e. d.	11	10	11	11	10	10	10	11	11
i.	7	7	7	7	6	7	8	7	7
Scales K.	11	10	10	11	10	10	11	12	11
Scales L.	55	54	53	54	52	54	54	53	52
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	17 17	18 18	17 17	17 17	17 17	17 17	17 17	17 16	17 17
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 8	9 9
D. Fin	19	19	17	17	18	18	17	18	18
A. Fin	16	16	13	16	13	17	15	14	15
Total V.	54	53	52	53	53	55	54	54	53
A. V.	25	24	24	24	24	25	24	24	24
C. V.	29	29	28	29	29	30	30	30	29
G. Ra.	65	64	65	68	66	65	68	63	66
Br.	8 8	9 8	8 7	7 7	7 7	8 7	7 7	8 8	8 8

885	681	892	918	1007	815	854	826	828	886	940
♀	♀	♀	♀	♀	♂	♀	♂	♀	♀	♀
4	4	4	4	4	4	4	4	4	4	4
79	82	87	71	94	74	90	80	64	77	99
188	195	196	187	196	187	195	189	181	190	202
42	42	43	41	43	42	43	41	41	43	44
20	19	20	19	20	19	19	20	18	20	20
11	11	11	11	11	11	11	11	11	12	12
19	18	20	19	20	19	20	19	20	20	20
11	11	11	10	10	10	10	10	10	10	10
6	7	7	6	7	7	7	6	6	7	7
11	10	11	11	11	11	11	10	10	10	11
55	56	51	54	51	55	52	54	56	52	52
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
16 16	17 17	18 18	17 17	18 18	18 17	18 18	17 17	17 18	17 17	18 19
9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
17	18	19	19	19	19	19	17	18	18	19
16	17	13	16	15	16	17	16	16	17	17
53	53	51	54	53	53	53	55	53	52	53
25	25	25	24	23	24	24	25	25	25	24
28	28	26	30	30	29	29	30	28	27	29
68	68	65	69	66	66	64	67	65	67	66
7 7	8 8	6 7	8 8	8 8	8 8	7 7	9 8	8 7	-	8 8

TUK

Number	825	936	971	1003	806	935	929	888	944
Sex	♀	♀	♀	♀	♂	♂	♀	♂	♂
Age	4	4	5	4	4	-	-	4	4
Wt.	80	81	90	93	100	75	88	84	90
F. L.	190	194	197	196	207	182	195	189	195
H. L.	42	44	41	44	45	43	43	41	42
u. j.	19	20	19	20	20	20	20	18	19
m.	12	11	11	11	12	11	11	11	12
p. o.	20	20	19	20	21	20	20	19	20
e. d.	10	11	11	10	11	11	10	10	10
i.	7	8	7	7	8	7	7	7	7
Scales K.	11	11	11	11	12	11	12	11	11
Scales L.	52	51	52	53	55	55	53	54	54
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	18 18	16 16	17 17	16 16	16 17	16 17	16 16	18 18	17 17
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	19	18	18	19	21	17	20	19	18
A. Fin	17	14	15	16	15	15	14	16	15
Total V.	53	52	54	53	53	-	53	54	53
A. V.	25	24	25	24	24	-	23	25	24
C. V.	28	28	29	29	29	-	30	29	29
G. Ra.	65	70	67	66	67	64	68	64	70
Br.	8 9	7 7	7 7	8 8	7 7	8 8	7 7	-	8 8

985	654	808	997	942	717	895	722	753	877	665
♀	♂	♂	♂	♀	♀	♂	♀	♂	♂	♀
-	5	4	4	4	4	-	3	4	4	3
98	87	70	80	105	68	83	65	66	67	60
200	192	183	188	198	183	180	184	180	179	175
45	43	41	42	44	42	41	41	41	40	39
21	20	18	19	21	19	18	19	18	18	17
12	11	11	11	12	11	10	11	10	10	9
21	20	17	19	20	20	19	19	19	19	18
11	11	9	11	11	10	10	10	10	10	10
7	7	7	6	7	6	6	6	7	7	6
11	11	12	10	10	12	11	11	11	9	11
54	53	54	54	54	53	54	52	55	52	53
6	6	6	6	6	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
16 17	17 17	16 16	16 16	17 17	17 17	16 16	18 17	18 19	18 18	17 17
8 9	9 9	10 10	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
18	19	19	18	19	19	18	19	18	18	18
16	15	17	16	16	17	16	15	16	16	16
53	54	52	52	53	52	54	53	53	54	53
25	26	25	24	25	23	26	24	25	25	24
28	28	27	28	28	29	28	29	28	29	29
64	65	65	63	66	65	66	64	68	65	60
7 7	7 7	7 7	8 7	7 7	8 9	8 8	8 8	9 8	- -	7 7

TUK

Number	817	827	676	884	966	993	897	959	822	984
Sex	♀	♂	♂	♀	♀	♀	♂	♀	♀	♀
Age	4	4	4	4	4	4	4	4	4	4
Wt.	76	64	60	87	95	91	80	75	75	95
F. L.	185	183	177	193	195	190	189	179	190	198
H. L.	41	40	40	42	43	42	43	40	42	45
u. j.	19	19	18	19	20	19	18	18	19	21
m.	11	11	10	11	11	11	11	10	11	12
p. o.	19	19	18	20	20	20	20	19	19	20
e. d.	10	10	10	11	11	10	10	10	11	11
i.	7	7	6	7	7	7	7	6	6	7
Scales K.	10	11	10	11	11	11	10	10	10	11
Scales L.	52	53	53	51	53	54	54	52	53	52
Scales D.	6	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6	6
Pt. Fin	16 16	16 17	18 18	17 17	17 17	18 17	17 16	17 17	17 16	17 17
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	18	18	17	19	18	19	17	19	18	19
A. Fin	16	14	16	16	15	15	17	15	16	18
Total V.	53	54	54	54	53	53	55	52	53	53
A. V.	25	24	24	24	24	25	27	23	24	25
C. V.	28	30	30	30	29	28	28	29	29	28
G. Ra.	65	63	68	64	69	67	66	68	66	66
Br.	8 8	8 8	9 8	8 8	7 7	7 8	9 8	8 8	8 8	7 7

887	805	924	938	965	952	925	943	912	804	949
♂	♀	♀	♂	♂	♂	♀	♂	♀	♂	♀
4	6	6	8	6	8	7	7	7	6	12
102	225	230	260	250	275	275	290	290	272	475
202	253	250	253	250	265	269	269	263	266	338
43	55	55	55	53	57	57	54	55	56	71
19	25	25	25	24	25	22	24	25	25	32
11	15	14	15	14	15	16	14	15	15	19
20	26	26	25	25	27	26	26	26	27	35
10	13	13	13	12	13	13	13	12	13	16
7	9	10	10	10	10	10	10	10	10	13
11	10	11	11	11	11	10	11	11	11	-
53	54	55	52	54	54	53	54	52	53	-
6	6	6	6	6	6	6	6	6	6	-
6	6	6	6	6	6	6	6	6	6	-
17 17	18 18	16 16	16 16	17 17	17 17	17 17	18 18	17 17	16 17	16 16
9 8	9 9	9 9	9 9	9 9	10 9	9 9	9 9	8 9	9 9	- -
19	19	18	17	19	19	18	18	18	18	-
17	17	16	16	18	16	17	18	17	17	-
55	53	52	53	55	53	53	54	52	53	-
26	23	24	23	26	24	24	25	24	24	-
29	30	28	30	29	29	29	29	28	29	-
65	68	68	65	70	69	68	63	66	63	69
7 7	8 8	9 8	8 7	8 9	8 8	9 8	8 8	7 7	8 6	8 7

TUK

Number	684	671
Sex	-	-
Age	13	13
Wt.	400	410
F. L.	314	319
H. L.	-	-
u. j.	-	-
m.	-	-
p. o.	-	-
e. d.	-	-
i.	-	-
Scales K.	-	-
Scales L.	-	-
Scales D.	-	-
Scales V.	-	-
Pt. Fin	-	-
Pl. Fin	-	-
D. Fin	-	-
A. Fin	-	-
Total V.	53	53
A. V.	26	24
C. V.	27	29
G. Ra.	-	-
Br.	-	-

HUSKY LAKES

Number	244	257	246	256	253	248	258	255	245
Sex	♂	♀	♂	♂	♀	♀	♂	♀	♂
Age	-	9	-	8	9	11	13	9	7
Wt.	195	162	182	127	167	210	234	181	149
F. L.	261	263	258	231	253	267	274	265	238
H. L.	57	56	57	49	56	58	60	56	52
u. j.	26	26	25	23	26	28	28	25	24
m.	14	14	13	12	13	14	14	14	13
p. o.	26	25	25	22	24	27	27	26	24
e. d.	14	14	13	12	13	14	14	14	13
i.	9	9	9	8	9	10	10	10	8
Scales K.	11	11	11	11	11	11	11	12	11
Scales L.	55	56	54	55	55	55	53	57	53
Scales D.	6	6	6	6	6	6	6	6	6
Scales V.	6	6	6	6	6	6	6	6	6
Pt. Fin	18 18	17 17	18 17	17 17	18 18	17 17	19 19	16 16	17 18
Pl. Fin	9 9	9 9	9 9	9 9	9 8	9 9	9 9	8 9	9 9
D. Fin	17	18	17	19	17	18	17	18	18
A. Fin	17	17	16	16	17	17	18	17	16
Total V.	53	53	52	-	53	53	52	53	53
A. V.	24	25	24	-	25	24	24	25	24
C. V.	29	28	28	-	28	29	28	28	29
G. Ra.	65	67	70	72	68	65	62	65	68
Br.	8 8	7 7	8 7	8 8	9 8	9 8	8 8	7 7	7 7

198	254	260	252	262	259	199	247	250	264	263
♂	♀	♀	♂	♂	♂	♂	♂	♂	♂	♂
9	-	7	7	9	7	7	11	9	7	13
159	187	135	139	204	135	162	218	165	137	236
258	258	232	239	267	231	253	274	243	243	275
54	57	50	53	58	51	55	59	53	52	59
25	26	22	25	28	23	25	27	25	23	28
14	15	13	14	16	14	15	16	14	14	16
24	26	22	25	27	23	25	25	24	23	25
13	13	12	12	13	13	13	14	13	12	14
9	10	8	9	10	8	9	10	9	8	10
12	11	10	11	11	11	11	12	12	12	12
54	53	54	54	53	53	54	53	53	55	55
6	6	6	5	5	6	6	6	6	6	6
6	6	6	6	6	6	6	6	6	6	6
17 17	17 18	16 16	18 18	17 18	17 17	17 17	18 17	17 17	17 17	17 17
9 9	9 9	9 9	9 -	9 9	9 9	10 9	9 9	9 9	9 9	9 9
18	18	16	19	18	18	18	19	18	19	17
-	17	16	16	17	17	17	18	16	17	17
53	53	53	52	53	-	53	52	-	54	52
24	25	26	23	24	-	25	24	-	25	24
29	28	27	29	29	-	28	28	-	29	28
66	67	67	66	65	68	68	70	66	66	66
7 8	7 8	7 7	8 8	9 9	7 7	8 8	9 8	8 8	8 7	8 8

	HUSKY LAKES		TUK
Number	267	243	222
Sex	♂	♂	♀
Age	5	9	-
Wt.	142	147	276
F. L.	243	247	295
H. L.	52	53	63
u. j.	24	25	30
m.	13	15	17
p. o.	24	23	30
e. d.	12	12	14
i.	8	9	12
Scales K.	12	12	13
Scales L.	54	56	55
Scales D.	6	6	6
Scales V.	6	6	6
Pt. Fin	17 17	17 17	17 17
Pl. Fin	9 9	9 9	9 9
D. Fin	18	18	18
A. Fin	17	17	17
Total V.	53	53	51
A. V.	24	27	24
C. V.	29	26	27
G. Ra.	67	63	67
Br.	8 8	8 8	8 8

ROYAL ONTARIO MUSEUM

Number	15,427	15,103	15,428	15,426	15,425	10,921
Sex	♂	♀	♀	♂	♀	♂
Age	11	10	11	13	13	-
Wt.	199	121	212	187		216
F. L.	268	255	274	283	273	295
H. L.	59	58	59	62	58	66
u. j.	28	26	27	29	26	30
m.	15	16	16	16	15	17
p. o.	27	27	27	29	27	31
e. d.	14	-	15	15	14	16
i.	10	9	10	11	10	12
Scales K.	12	12	11	10	12	11
Scales L.	55	60	56	54	54	54
Scales D.	6	6	6	6	6	6
Scales V.	6	7	6	6	6	6
Pt. Fin	17 18	17 17	16 16	18 18	17 17	17 17
Pl. Fin	9 9	9 9	9 9	9 9	9 9	9 9
D. Fin	18	18	18	18	17	18
A. Fin	16	16	17	17	17	17
Total V.	53	54	54	53	53	54
A. V.	24	26	26	23	25	25
C. V.	29	28	28	30	28	29
G. Ra.	67	69	67	70	64	69
Br.	8 8	8 7	7 7	8 8	8 7	8 8

10,920	10,922	10,911	10,923	15,490	15,104	10,271
♀	♀	♀	♀	♂	♂	♂
13	15	14	-	10	-	13
245	263	294	315	187	88	141
308	293	312	306	275	228	260
68	64	67	69	60	56	60
32	29	32	31	27	25	28
18	17	17	18	15	14	16
32	29	33	32	28	24	28
16	15	17	17	13	13	13
12	11	11	12.5	10	9	11
11	11	11	11	12	11	-
58	54	57	54	54	55	55
6	7	6	6	6	6	6
6	6	6	6	6	6	-
17 17	17 17	17 17	17 17	18 18	17 17	18 17
9 9	9 9	9 9	9 9	9 9	9 9	9 9
15	18	18	18	18	17	19
16	18	16	18	15	17	17
53	52	53	51	51	-	51
25	26	24	23	22	-	24
28	26	29	28	29	-	27
70	69	72	67	65	66	69
8 8	8 8	8 7	8 9	8 7	7 7	8 9